APPENDIX L
SUPPLEMENTAL RESPONSIVE SCENARIOS

1. Introduction

Four supplemental responsive scenarios are analyzed in this appendix based on comments received on the draft LTER report. One scenario examines the effects of a new combined cycle natural gas plant in Maryland that is on-line by 2015. The second scenario examines the impact of a set of combined events that could adversely affect electric power supply reliability without new power plant construction prior to the 2020 date indicated by the LTER Reference Case results. The third and fourth scenarios examine the impacts of additional levels of coal plant retirements in PJM due to new EPA regulations and other economic factors.

As discussed in Chapter 4, under the LTER Reference Case assumptions, new electric generating capacity is not expected to be required in Maryland until 2020. If certain LTER Reference Case assumptions deviate too significantly from actual future experience, the need for new generating capacity may emerge earlier than the 2020 date indicated by the LTER Reference Case results. For example, if energy efficiency and conservation savings do not materialize as reflected in the LTER Reference Case input assumptions, demand response is significantly below assumed levels, load growth is more rapid than projected, and/or power plant retirements are higher than expected, generating capacity additions may be required at an earlier date.

2. Early Natural Gas Plant Scenario

At the public meeting conducted on August 16, 2011, to solicit comments on the Draft LTER, Competitive Power Ventures ("CPV") requested that PPRP run a scenario that includes the early construction of a new natural gas plant in PJM-SW. Pursuant to that request, this scenario examines the effect of a new combined cycle natural gas plant being built early in Maryland along with the Mt. Storm to Doubs transmission line upgrade (NGP+MSD). A generic combined cycle natural gas unit, the characteristics of which are specified in Table 3.10 of the LTER, is added in 2015. In this section, the NGP+MSD scenario is compared to the LTER Reference Case scenario that contains the Mt. Storm to Doubs transmission upgrade (MSD).

2.1 Capacity Additions

Adding a new natural gas plant into the PJM-SW zone in 2015 reduces the number of new natural gas plants built by the model (auto-builds) by a single combined cycle unit. The auto-builds combined with the addition of the early natural gas plant, therefore, result in no change in the overall capacity built in the Maryland zones between the two scenarios; the timing of the builds, however, is affected. New natural gas builds in the other Maryland zones (PJM-APS and PJM-MidE) are unaffected during the study period (Table L-1).

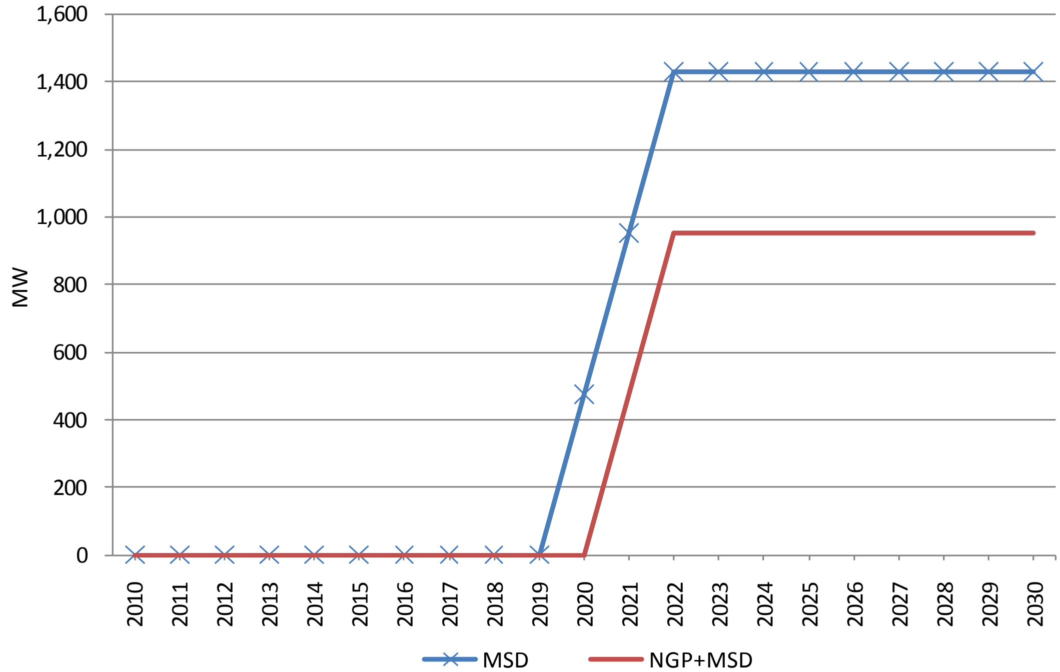
Table L-1 Cumulative Natural Gas Capacity Additions Through 2030 – Natural Gas Plant Scenario (MW)

Scenario	PJM-SW	PJM-MidE	PJM-APS	PJM Total
MSD	1,431	3,816	4,770	30,145
NGP + MSD	954	3,816	4,770	29,494

In PJM as a whole, the model auto-builds one less combined cycle unit (in PJM-SW, which is supplanted by the early-build unit) but also auto-builds one less peaking unit in PJM-South, a zone that is adjacent to PJM-SW. Total builds (planned plus generic) in PJM as a whole are reduced by a single peaking unit.

Adding the combined cycle unit in 2015 also delays the need to begin building additional new capacity in PJM-SW by one year (Figure L-1). Total builds over the study period in PJM-MidE and PJM-APS are unchanged, but PJM-MidE begins building capacity one year earlier in the NGP+MSD scenario (2021 rather than 2022). This result is caused by changes in power flows and inter-zonal imports and exports that are affected by the early addition of the natural gas plant in PJM-SW.

Figure L-1 PJM-SW Natural Gas Capacity Additions – Natural Gas Plant Scenario



2.2 Net Imports

Adding a natural gas plant in 2015 in PJM-SW changes the net import dynamics in all three Maryland zones. Figure L-2 shows net imports into PJM-SW over the study period. PJM-SW's net imports in the NGP+MSD scenario drop below the RC plus MSD scenario following the natural gas plant addition in 2015 but rise to the same level again by 2020. Post-2020, PJM-SW net imports increase beyond the levels seen in the RC plus MSD scenario.

During the 2015 to 2020 period, PJM MidE imports slightly more energy in the NGP+MSD scenario compared to the RC plus MSD scenario (see Figure L-3) due to the extra capacity available in PJM-SW. In the last 10 years of the study period, PJM-MidE imports slightly less in the NGP+MSD scenario compared to the RC plus MSD scenario. The PJM-APS zone (Figure L-4) exports significantly more under the NGP+MSD scenario compared to the RC plus MSD scenario. Additional imports are also made available from PJM-EPA, a low cost exporting zone adjacent to PJM-SW and PJM-MidE, which slightly reduces total generation in PJM-SW (in favor of being able to import from the lower-cost zones) in the last 10 years of the study period.

Figure L-2 PJM-SW Net Imports – Natural Gas Plant Scenario

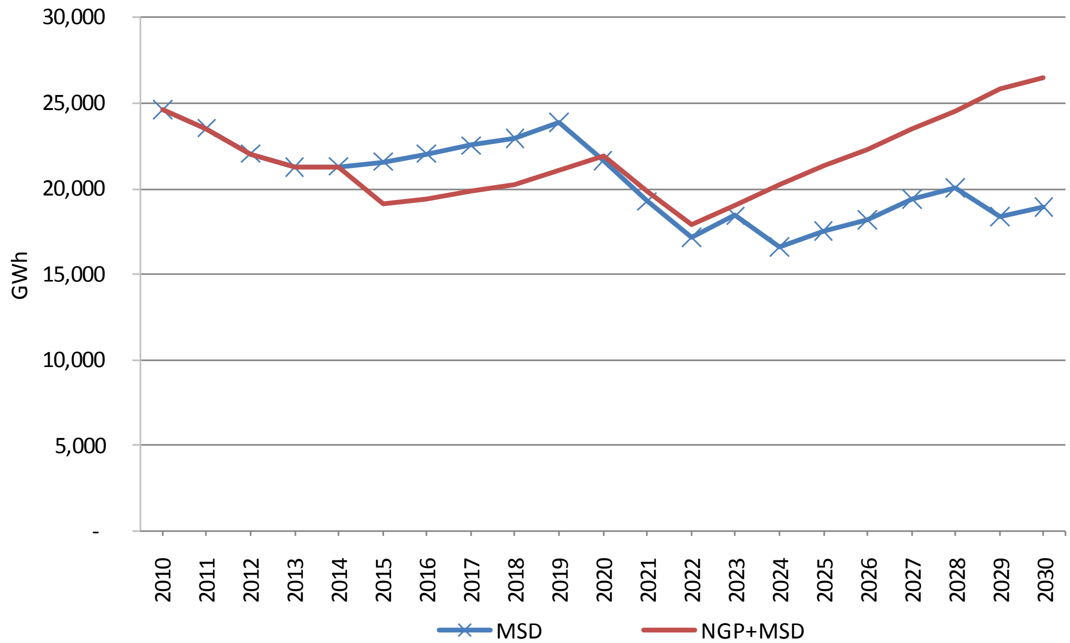


Figure L-3 PJM-MidE Net Imports – Natural Gas Plant Scenario

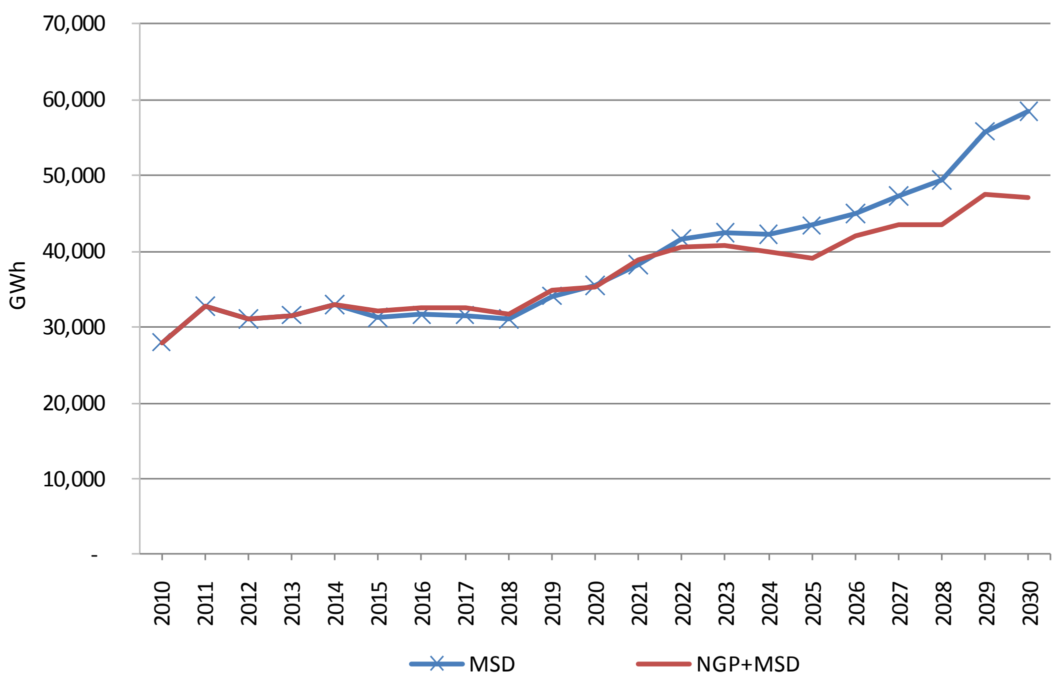
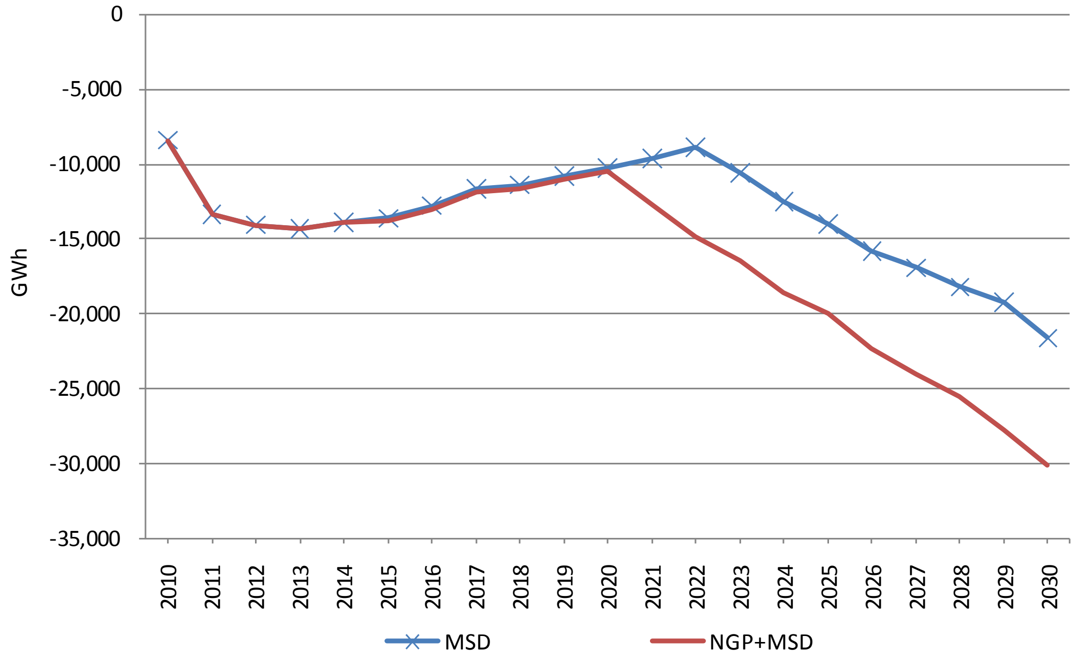


Figure L-4 PJM-APS Net Imports – Life Extension Scenario



2.3 Fuel Use

Natural gas use for electricity generation increases following the new plant build in 2015, but returns to the same levels as the LTER Reference Case plus Mt. Storm to Doubs by 2020 (see Figure L-5). However, as noted in Section 2.2 above, PJM-SW imports more energy in the NGP+MSD scenario compared to the RC plus MSD scenario and, therefore, natural gas usage is slightly lower by 2030, by about 962,000 mmBtu.

Coal use for electric generation in the NGP+MSD scenario increases in 2015 as the coal-fired units begin operating at increased capacity factors earlier than in the RC plus MSD scenario (see Figure L-6). Net imports drop significantly in PJM-SW following the early introduction of the natural gas plant leading to higher generation in the zone from all units as PJM-SW exports more through 2020 due to the extra capacity in the zone.

Figure L-5 Maryland Electric Generation Natural Gas Use – Natural Gas Plant Scenario

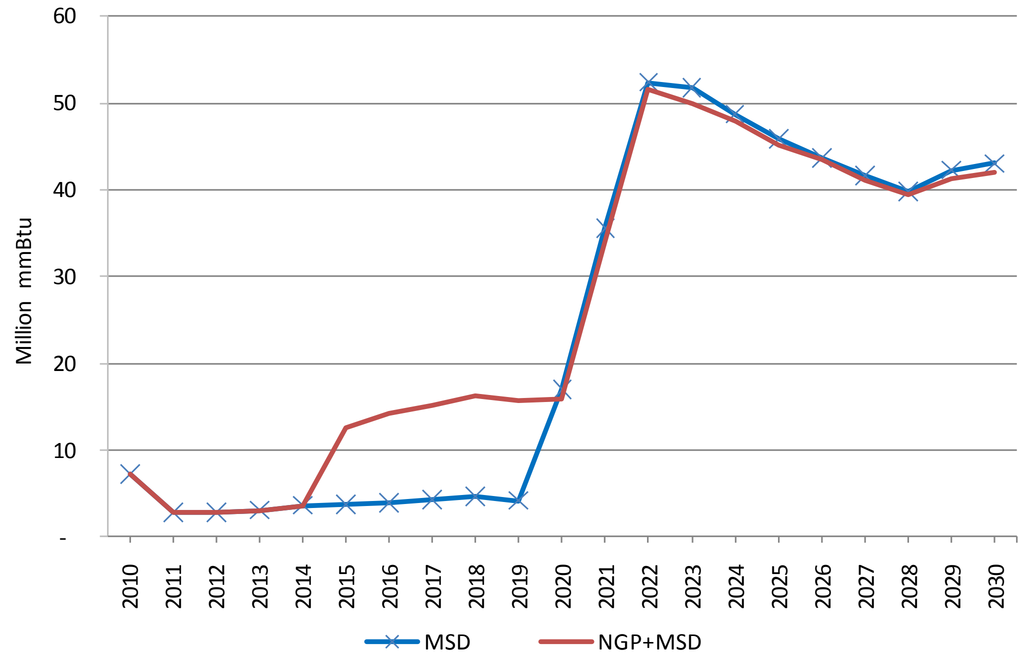
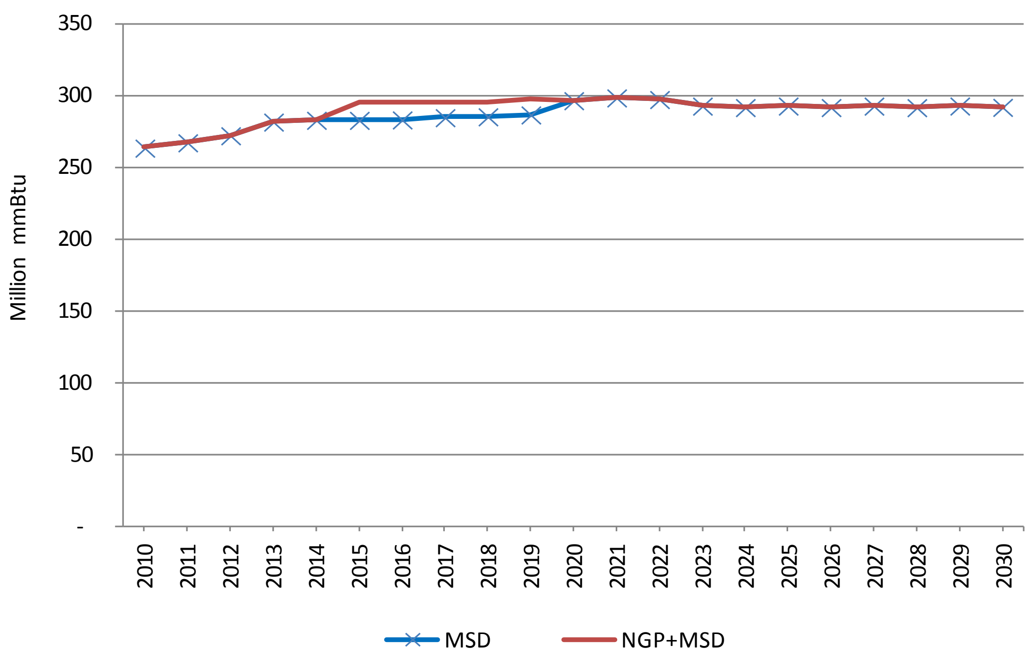


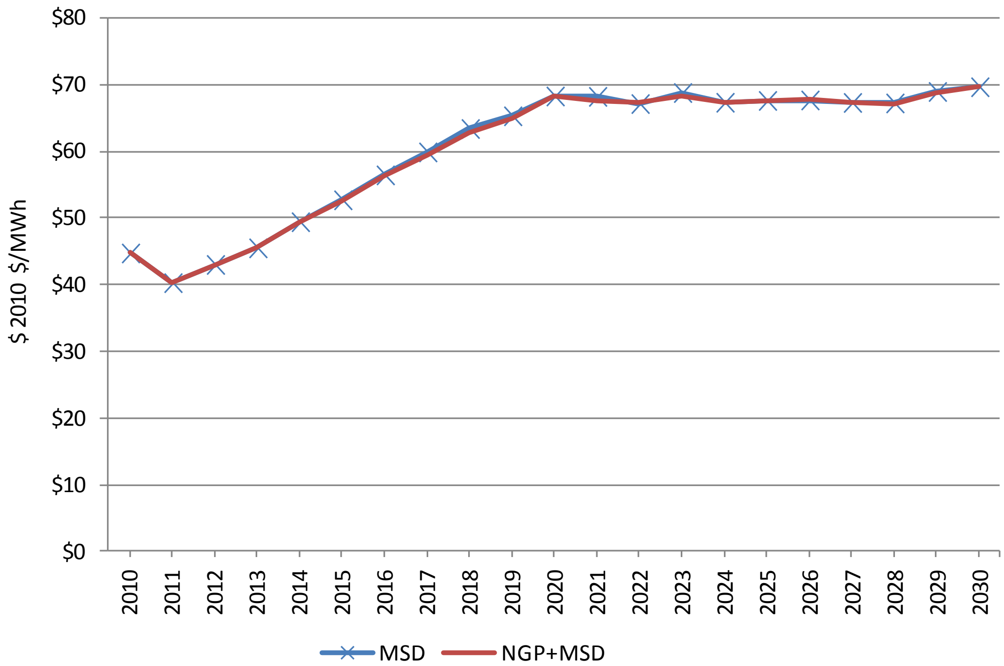
Figure L-6 Maryland Electric Generation Coal Use – Natural Gas Plant Scenario



2.4 Energy Prices

The early addition of a natural gas plant in PJM-SW does not have a significant impact on wholesale energy prices in any of the three Maryland zones. Figure L-7 shows energy prices for PJM-SW vary only slightly throughout the study period for the RC plus MSD and the NGP+MSD scenario.

Figure L-7 PJM-SW Real All-Hours Energy Price – Natural Gas Plant Scenario



Energy prices in PJM-MidE and PJM-APS under the NGP+MSD scenario are also only slightly changed relative to the RC plus MSD scenario energy prices.

The table below compares the annual average all-hours energy prices in each of the three zones for the RC plus MSD and NGP+MSD scenario. On average, annual wholesale energy prices in Maryland (2010$) decline by about $0.14 per MWh over the 20-year analysis period.

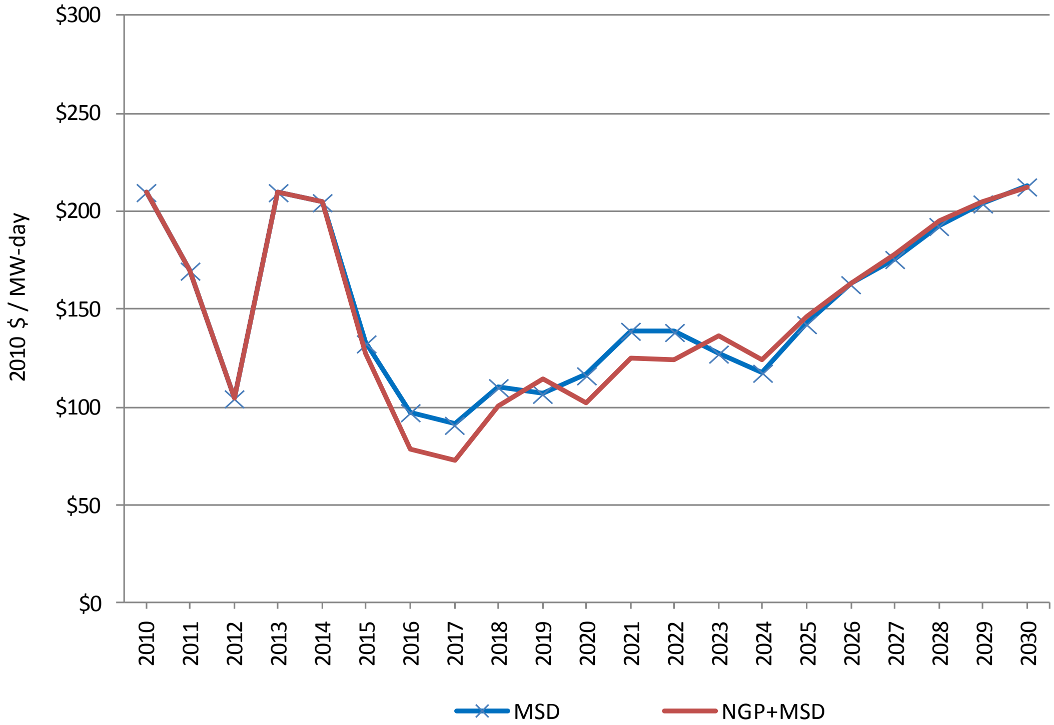
Table L-2 Real All-Hours Energy Price (2010 $/MWh)

	PJM-SW			PJM-MidE			PJM-APS		
Year	**MSD**	**NGP+ MSD**	**Delta**	**MSD**	**NGP+ MSD**	**Delta**	**MSD**	**NGP+ MSD**	**Delta**
2010	44.73	44.73	0	46.34	46.34	0	41.60	41.60	0
2011	40.28	40.28	0	42.78	42.78	0	38.99	38.99	0
2012	43.01	43.01	0	46.31	46.31	0	41.83	41.83	0
2013	45.50	45.50	0	48.97	48.97	0	44.41	44.41	0
2014	49.42	49.42	0	53.40	53.40	0	48.09	48.09	0
2015	52.70	52.52	-0.18	57.94	57.49	-0.45	51.75	51.30	-0.45
2016	56.44	56.26	-0.18	61.10	60.70	-0.4	55.75	55.27	-0.48
2017	59.88	59.48	-0.4	64.64	64.10	-0.54	59.12	58.51	-0.61
2018	63.39	62.80	-0.59	67.01	66.64	-0.37	62.51	61.87	-0.64
2019	65.30	64.97	-0.33	68.05	67.86	-0.19	64.34	64.05	-0.29
2020	68.27	68.37	0.1	69.72	69.70	-0.02	66.96	66.97	0.01
2021	68.21	67.48	-0.73	69.85	69.37	-0.48	67.18	66.54	-0.64
2022	67.14	67.40	0.26	69.10	68.94	-0.16	66.21	66.49	0.28
2023	68.79	68.31	-0.48	70.82	70.45	-0.37	67.61	67.17	-0.44
2024	67.33	67.39	0.06	69.02	69.16	0.14	66.25	66.32	0.07
2025	67.60	67.64	0.04	69.47	69.44	-0.03	66.44	66.37	-0.07
2026	67.67	67.71	0.04	70.02	70.16	0.14	66.63	66.64	0.01
2027	67.30	67.39	0.09	70.00	70.18	0.18	66.00	66.06	0.06
2028	67.23	67.14	-0.09	70.36	70.28	-0.08	66.03	65.90	-0.13
2029	68.95	68.76	-0.19	71.29	71.09	-0.2	66.74	66.70	-0.04
2030	69.66	69.60	-0.06	72.11	71.94	-0.17	68.13	68.16	0.03
Average Difference (NGP+MSD – MSD)									
2010-2020	-0.14			-0.18			-0.22		
2021-2030	-0.11			-0.10			-0.09		
2010-2030	-0.13			-0.14			-0.16		

2.5 Capacity Prices

Capacity prices in PJM-SW under the NGP+MSD scenario are very similar to the capacity prices in the RC plus MSD scenario throughout the period but are slightly lower in the 2015 to 2023 timeframe given the increased generating capacity in the zone (Figure L-8). However, for the last five years of the study period, capacity prices under the NGP+MSD scenario are almost identical to the RC plus MSD scenario.

Figure L-8 PJM-SW Capacity Prices – Natural Gas Plant Scenario



In the PJM-MidE zone, capacity prices under the NGP+MSD scenario begin to rise a year earlier due to the fact that the model begins building capacity in that zone one year earlier. However, following that shift, capacity prices stay on the same track for the rest of the study period (see Figure L-9). PJM-APS capacity prices are only marginally affected by the early capacity addition in PJM-SW (see Figure L-10).

Figure L-9 PJM-MidE Capacity Prices – Natural Gas Plant Scenario

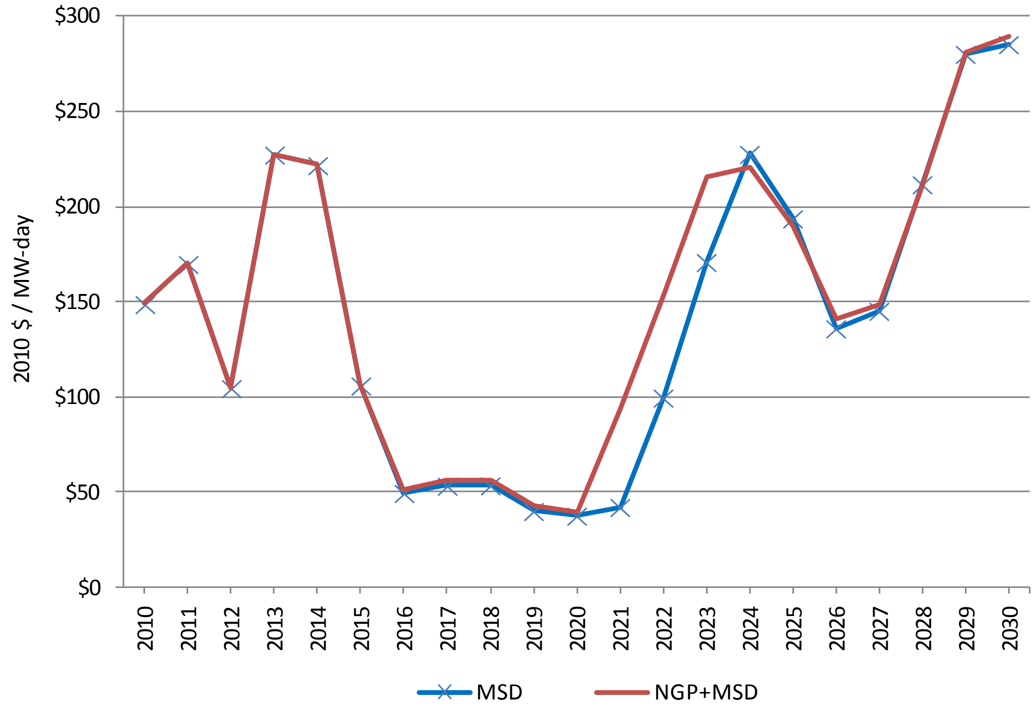


Figure L-10 PJM-APS Capacity Prices – Natural Gas Plant Scenario

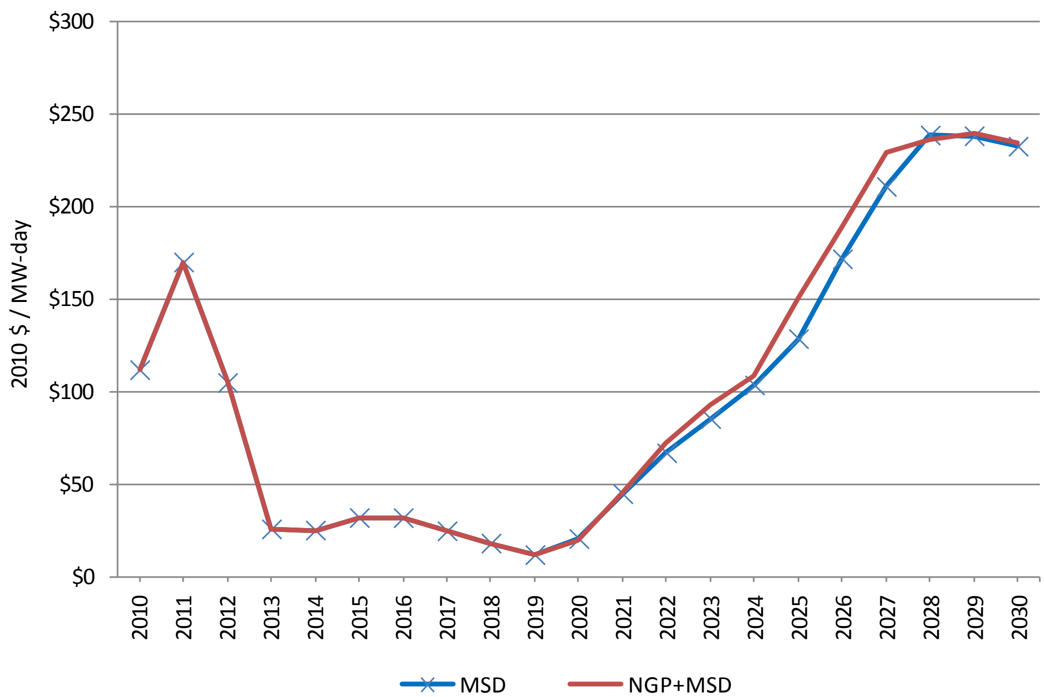


Table L-3, below, compares the capacity prices for each of the zones under each of the two scenarios.

Table L-3 Real Capacity Prices (2010 $/MW-day, 3-year moving average)

	PJM-SW			PJM-MidE			PJM-APS		
Year	**MSD**	**NGP+ MSD**	**Delta**	**MSD**	**NGP+ MSD**	**Delta**	**MSD**	**NGP+ MSD**	**Delta**
2010	210.08	210.08	0	148.93	148.93	0	111.78	111.78	0
2011	170.00	170.00	0	170.00	170.00	0	170.00	170.00	0
2012	104.83	104.83	0	104.83	104.83	0	104.83	104.83	0
2013	210.04	210.04	0	227.44	227.44	0	25.64	25.64	0
2014	204.92	204.92	0	221.90	221.90	0	25.02	25.02	0
2015	132.87	127.20	-5.67	106.22	106.89	0.67	31.77	31.77	0
2016	97.75	78.35	-19.40	49.77	51.36	1.59	31.73	31.73	0
2017	91.32	73.07	-18.25	53.61	55.91	2.30	24.61	24.61	0
2018	110.53	100.69	-9.84	53.82	56.60	2.78	17.97	17.97	0
2019	107.13	114.11	6.98	40.32	42.53	2.21	11.73	11.47	-0.26
2020	116.58	102.49	-14.09	37.87	39.27	1.40	20.42	19.75	-0.67
2021	139.31	124.80	-14.51	42.43	93.78	51.35	44.67	45.79	1.12
2022	138.70	124.36	-14.34	99.86	153.41	53.55	66.79	72.22	5.43
2023	127.66	136.06	8.40	171.04	215.21	44.17	85.29	93.00	7.71
2024	117.91	124.04	6.13	227.81	220.67	-7.14	103.50	108.73	5.23
2025	142.70	146.01	3.31	193.97	189.60	-4.37	128.57	150.42	21.85
2026	163.08	163.52	0.44	136.22	140.95	4.73	171.71	189.18	17.47
2027	175.92	177.91	1.99	145.42	148.41	2.99	210.86	229.01	18.15
2028	192.77	195.35	2.58	211.86	211.66	-0.20	238.68	236.36	-2.32
2029	204.30	205.06	0.76	280.30	280.59	0.29	238.29	239.30	1.01
2030	212.96	211.99	0.76	285.44	288.92	3.48	232.65	234.16	1.51
Average Difference (NGP+MSD – MSD)									
2010-2020	-5.48			1.00			-0.08		
2021-2030	0.45			14.89			7.72		
2010-2030	-3.08			7.61			3.63		

2.6 Energy and Capacity Cost Differentials

Table L-4 and Table L-5 show the estimated Maryland energy and capacity cost differentials, respectively, for the NGP+MSD scenario relative to the LTER Reference Case plus MSD scenario, in aggregate and by zone, over the 20-year analysis period. These data were computed by multiplying the energy and capacity price differentials by Maryland energy consumption (by zone) and capacity requirements (by zone), respectively. In aggregate, energy costs under the NGP+MSD scenario are $201 million (2010$) less than under the LTER Reference Case plus MSD scenario; capacity costs are $155 million (2010$) lower.

Table L-4 Estimated Maryland Energy Cost Differentials
Early Natural Gas Plant Scenario

	Maryland Energy Cost Differentials [NGP+MSD] - [MSD] (millions of 2010$)			
Year	**Maryland**	**PJM-SW**	**PJM-MidE**	**PJM-APS**
2010	0.0	0.0	0.0	0.0
2011	0.0	0.0	0.0	0.0
2012	0.0	0.0	0.0	0.0
2013	0.0	0.0	0.0	0.0
2014	0.0	0.0	0.0	0.0
2015	-16.4	-10.0	-2.6	-3.8
2016	-16.6	-10.1	-2.4	-4.1
2017	-31.1	-22.7	-3.2	-5.2
2018	-41.6	-33.8	-2.2	-5.5
2019	-22.8	-19.1	-1.2	-2.5
2020	5.9	5.9	-0.1	0.1
2021	-52.0	-43.3	-3.0	-5.7
2022	17.1	15.6	-1.0	2.5
2023	-35.5	-29.1	-2.3	-4.0
2024	5.2	3.7	0.9	0.6
2025	1.6	2.5	-0.2	-0.6
2026	3.5	2.5	0.9	0.1
2027	7.4	5.7	1.2	0.6
2028	-7.5	-5.7	-0.5	-1.2
2029	-14.0	-12.3	-1.3	-0.4
2030	-4.8	-3.9	-1.1	0.3
Sum	-201.3	-154.2	-18.3	-28.8

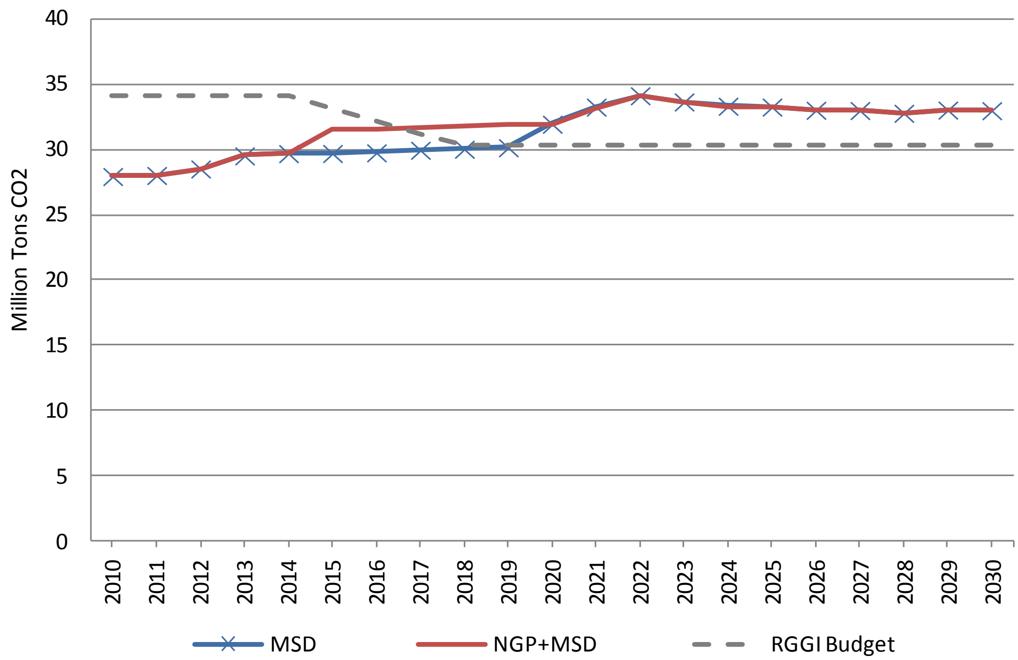
Table L-5 Estimated Maryland Capacity Cost Differentials
Early Natural Gas Plant Scenario

	Maryland Capacity Cost Differentials [NGP+MSD] - [MSD] (millions of 2010$)			
Year	**Maryland**	**PJM-SW**	**PJM-MidE**	**PJM-APS**
2010	0.0	0.0	0.0	0.0
2011	0.0	0.0	0.0	0.0
2012	0.0	0.0	0.0	0.0
2013	0.0	0.0	0.0	0.0
2014	0.0	0.0	0.0	0.0
2015	-25.9	-26.2	0.4	0.0
2016	-89.7	-90.6	0.9	0.0
2017	-84.9	-86.1	1.3	0.0
2018	-45.4	-46.9	1.5	0.0
2019	34.8	33.7	1.2	-0.2
2020	-68.8	-69.1	0.8	-0.5
2021	-41.7	-71.8	29.3	0.8
2022	-36.9	-71.7	30.9	3.9
2023	73.8	42.5	25.8	5.6
2024	30.9	31.3	-4.2	3.8
2025	30.6	17.1	-2.6	16.1
2026	18.2	2.3	2.9	13.1
2027	26.0	10.5	1.8	13.7
2028	11.8	13.7	-0.1	-1.8
2029	5.0	4.1	0.2	0.8
2030	7.4	4.1	2.2	1.2
Sum	-154.7	-303.3	92.2	56.5

2.7 Emissions

As noted in Section 2.3, coal use increases five years earlier in the NGP+MSD scenario compared to the RC plus MSD scenario and, therefore, SO_2 and NO_x emissions from plants subject to the Maryland Healthy Air Act also increase. However, these converge to the same levels by 2020 and are virtually identical for the remainder of the study period. Carbon dioxide emissions resulting from generation in Maryland are also increased slightly for the five years following the early natural gas capacity addition under the NGP+MSD scenario relative to the RC plus MSD scenario but are virtually identical for the remainder of the study period (Figure L-11). This transitory differential is the result of incremental emissions from the early natural gas plant, combined with the increase in capacity factors associated with Maryland's existing coal-fired plants (relative to the LTER Reference Case plus MSD scenario) that result from early natural gas plant development.

Figure L-11 Maryland Electric Generation CO_2 Emissions – Natural Gas Plant Scenario



2.8 Interpretation of Results

The results presented in this section are subject to the same caveats as are applicable to the results presented elsewhere in this report. Specifically, the results are dependent upon a wide range of assumptions regarding factors such as future load levels, fuel prices, power plant O&M costs, environmental regulations, and RPS requirements. To the extent that actual future values of these factors differ from the assumed values, results would differ.

As we have noted, the estimated aggregate energy and capacity cost reduction data presented in this appendix are obtained by multiplying the per-MWh and per-MW-day price differentials by the aggregate MWh and MW for Maryland, respectively, for each year over the 20-year analysis period. While the per-MWh and per-MW-day price differentials tend to be small, these are multiplied by a large number of MWh and MW. Consequently, even slight deviations in the per-MWh and per-MW-day prices from those estimated result in non-trivial cost impacts.

It should be noted that the analysis presented in this section represents the results of a single comparison of two scenarios. Comparisons with alternative scenarios that could include nuclear power plant development (e.g., Calvert Cliffs Nuclear Unit No. 3), new gas plant development in years other than 2015, natural gas plant development in different zones, or combinations of these variations, would provide different results.

3. Combined Events Scenario

The assumptions developed for this scenario are based on concerns that several simultaneous events may develop, or not develop as expected, putting Maryland energy supply reliability at potential risk. Several issues combined could potentially lead to a need for new capacity in the State earlier than forecast in the LTER Reference Case. The assumptions in this scenario involve the following series of events occurring together that could adversely impact energy supply:

- New EPA regulations could cause large-scale retirements of generating capacity.
- Natural gas prices may be lower than assumed for the LTER Reference Case.
- The load forecast may suddenly increase, i.e., the current load forecast may be in error and future loads may be larger than presently expected.
- State and federal emissions legislation could raise the cost of baseload generation.
- Planned transmission projects may not be completed as scheduled.
- Demand response ("DR") resources will not continue to grow at their current pace or the market rules supporting demand response will limit the extent to which DR can participate in PJM's capacity market.

Based on the concerns outlined above, Maryland may need new natural gas capacity earlier than indicated by the LTER Reference Case results. As such, the assumptions developed for this scenario reflect the concerns identified above.

For the Combined Events ("CE") scenario, the demand response capacity in PJM is reduced to a maximum of 12,269 MW by 2015 and then held constant thereafter. Load growth is increased to a level halfway between the LTER Reference Case load growth and High Load scenario load growth. The level of power plant retirements in PJM is exogenously increased to approximately 30.3 GW by 2015; 25 GW of new retirements in addition to the 5.3 GW of total power plant retirements by 2015 that were represented in the LTER Reference Case. Of the 25 GW of additional capacity that retires by 2015, 5.7 GW were already slated to retire due to age before 2030 in the LTER Reference Case but retirement of those plants has been accelerated to the 2015 timeframe for the CE scenario. In PJM-SW, an additional 404 MW retires in 2015 that was originally set to retire later in the analysis period. In addition, the CE scenario utilizes the low natural gas price assumption which could adversely affect the economics of coal-fired generation and potentially induce additional coal-plant retirements.

3.1 Capacity Additions

Capacity additions in the CE scenario begin earlier than in the LTER Reference Case due to the significantly increased power plant retirements and lower natural gas prices. As shown in Table L-6, all PJM zones begin adding combined cycle natural gas power plants in 2015.

Table L-6 Cumulative Generic Capacity Additions in PJM

Year	PJM-AEP	PJM-APS	PJM-CE	PJM-S	PJM-MidE	PJM-EPA	PJM-SW	PJM-WPA	CIN	FE-ATSI	PJM Total
2010	-	-	-	-	-	-	-	-	-	-	-
2011	-	-	-	-	-	-	-	-	-	-	-
2012	-	-	-	-	-	-	-	-	-	-	-
2013	-	-	-	-	-	-	-	-	-	-	-
2014	-	-	-	-	-	-	-	-	-	-	-
2015	1,217	477	696	1,650	1,997	477	477	1,173	174	522	8,859
2016	1,565	954	1,043	2,604	3,647	954	1,128	1,650	348	696	14,588
2017	1,739	1,431	1,217	3,602	3,821	1,431	2,127	2,127	522	1,173	19,189
2018	2,435	1,908	1,913	4,253	3,821	1,908	2,604	2,604	696	1,650	23,790
2019	2,609	2,385	2,087	4,730	3,821	2,385	2,951	3,081	696	2,127	26,871
2020	3,086	2,862	2,261	5,207	3,821	2,862	3,299	3,558	1,173	2,604	30,731
2021	3,563	3,339	2,261	5,684	3,995	3,339	3,473	4,035	1,650	3,081	34,418
2022	4,084	3,816	2,609	6,554	5,038	3,513	3,473	4,512	1,824	3,255	38,676
2023	4,258	4,293	2,782	7,205	5,560	3,513	3,647	4,989	1,824	3,732	41,802
2024	4,735	4,770	2,782	7,682	6,603	3,513	3,821	5,466	1,824	4,209	45,404
2025	5,083	5,247	2,956	8,159	7,125	3,513	3,821	5,943	1,997	4,382	48,226
2026	5,083	5,724	2,956	8,636	8,342	3,513	3,995	6,420	1,997	4,382	51,048
2027	5,083	6,201	2,956	9,287	8,690	3,513	4,169	6,941	1,997	4,859	53,697
2028	5,257	6,375	3,130	10,330	8,864	3,990	4,517	7,463	1,997	4,859	56,782
2029	5,734	6,375	3,130	10,981	9,212	3,990	4,994	7,637	1,997	4,859	58,909
2030	6,211	6,375	3,130	11,458	9,560	4,467	4,994	8,114	1,997	5,336	61,641

All three Maryland zones begin adding new capacity in 2015 with the first combined cycle plant going into PJM-SW in 2015, which then continues to add capacity almost yearly through the end of the analysis period. Capacity additions in PJM-SW total 4,994 MW by 2030 and 61,641 MW in PJM as a whole compared to the LTER Reference Case where 2,385 MW were constructed in PJM-SW by 2030 and 30,101 MW in PJM. The following three graphs show the capacity additions in the CE scenario compared to the LTER Reference Case.

Figure L-12 PJM-SW Capacity Additions – Combined Events Scenario

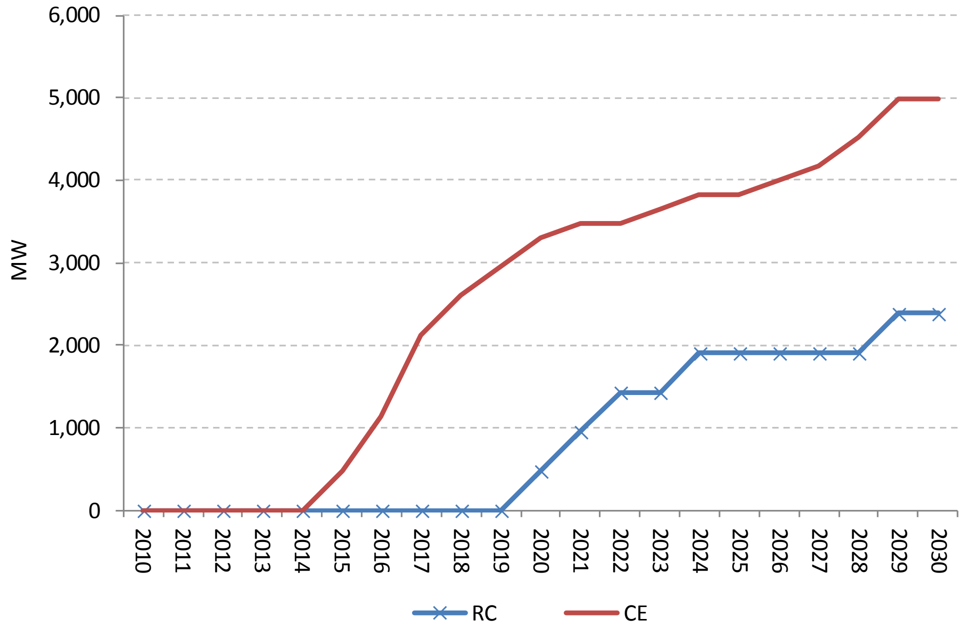


Figure L-13 PJM-MidE Capacity Additions – Combined Events Scenario

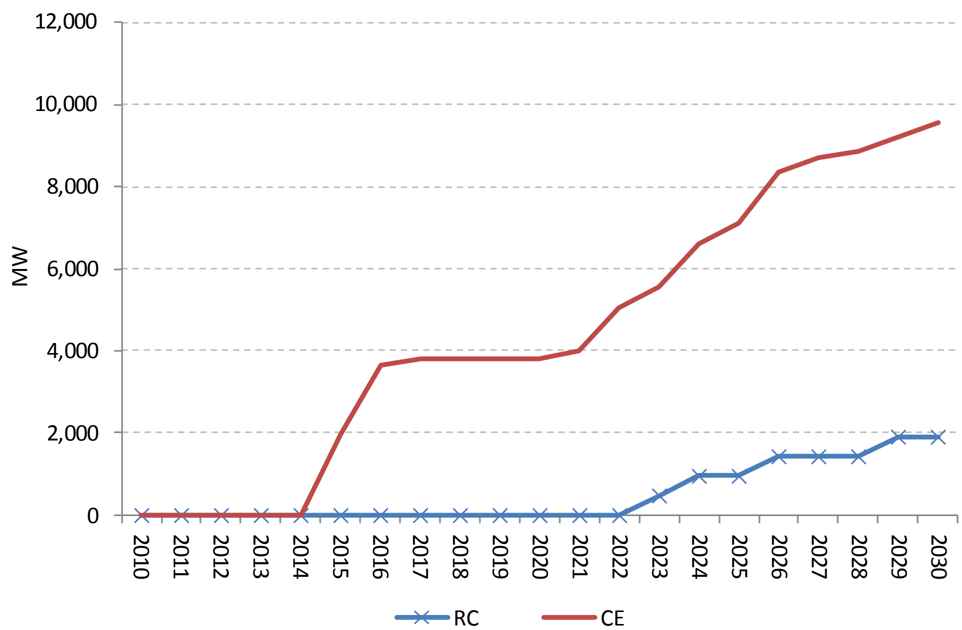
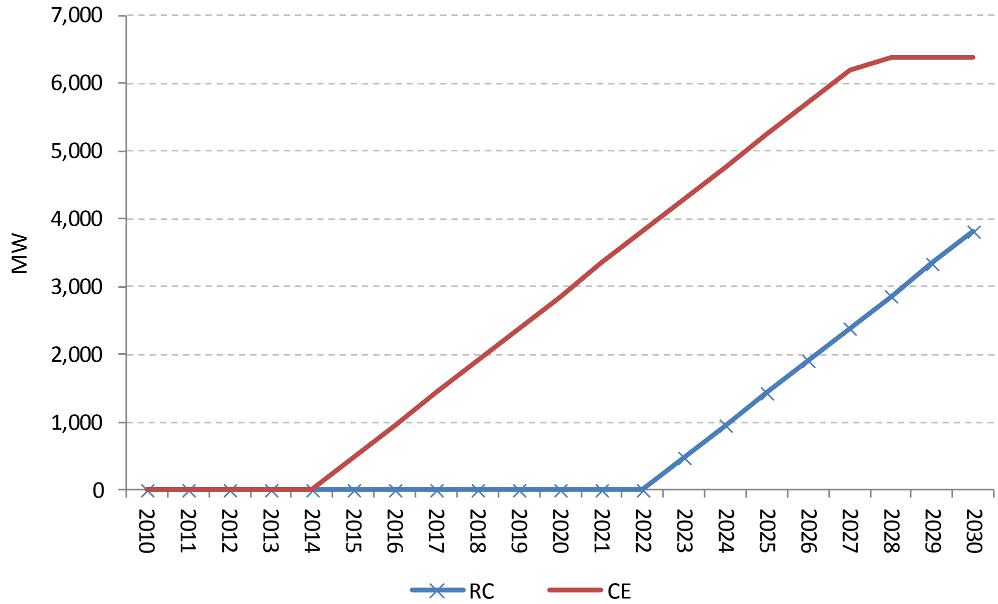


Figure L-14 PJM-APS Capacity Additions – Combined Events Scenario



3.2 Net Imports

Net imports in PJM-SW and PJM-MidE are not as strongly affected as net imports in PJM-APS in the CE scenario, mainly due to the relatively large number of capacity additions in the PJM-SW and PJM-MidE zones. PJM-SW net imports are reduced during the first five years that capacity is being added in the zone, then steadily increase for several years before beginning to converge towards the LTER Reference Case result in the last few years of the study period. PJM-APS exports more energy in general in the CE scenario as PJM-APS is one of main energy exporting zones in PJM. The graphs below show the net imports for the Maryland zones.[1]

[1] Note that the natural gas price forecast is lower in the CE scenario than in the LTER Reference Case beginning in 2010 and therefore the results for net imports and energy prices differ between the scenarios beginning in 2010.

Figure L-15 PJM-SW Net Imports – Combined Events Scenario

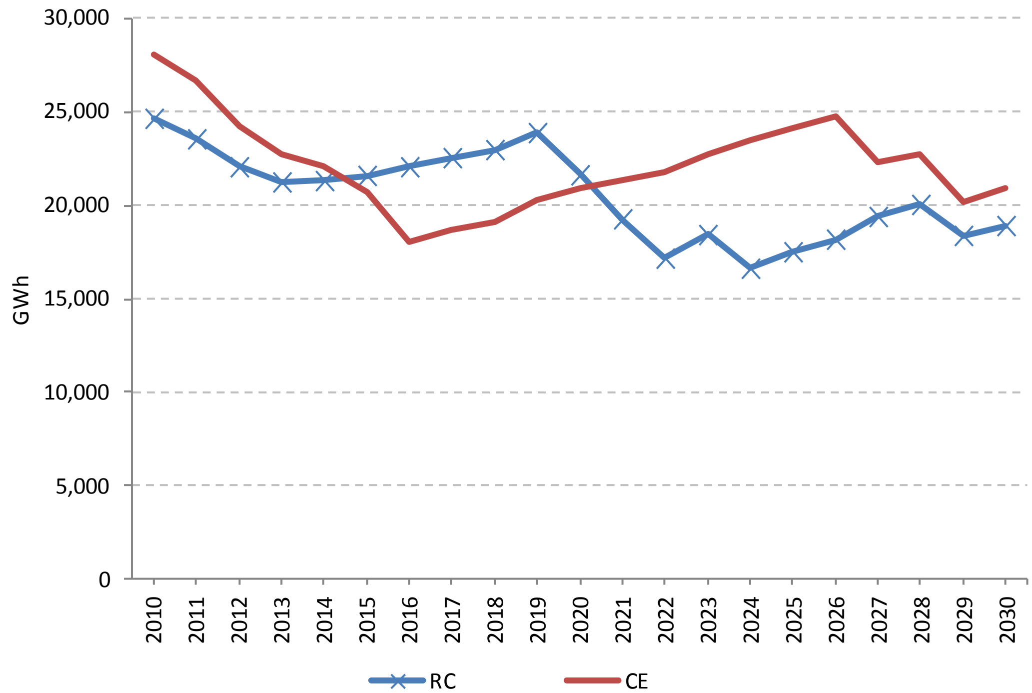


Figure L-16 PJM-MidE Net Imports – Combined Events Scenario

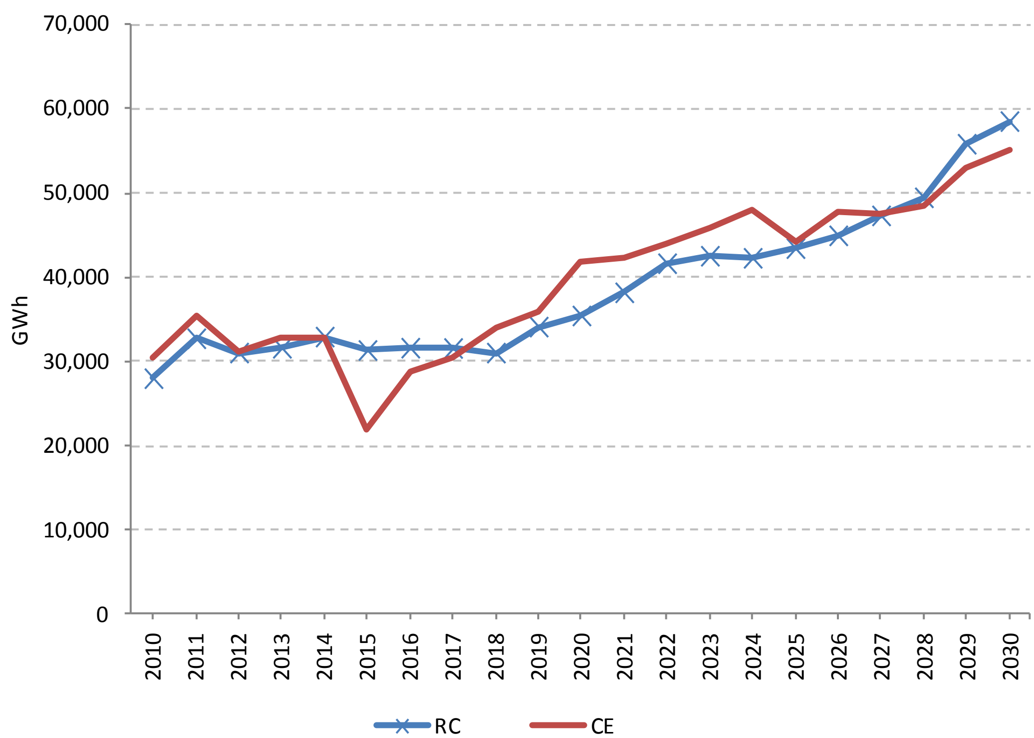
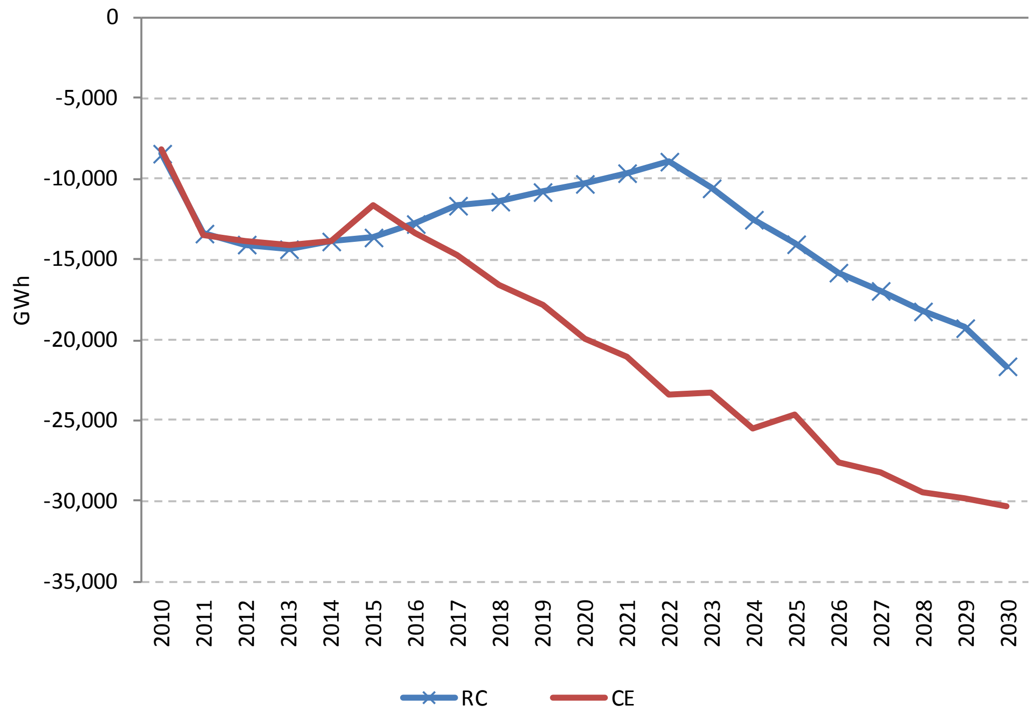


Figure L-17 PJM-APS Net Imports – Combined Events Scenario



3.3 Energy Prices

Energy prices in all of PJM are significantly affected by the combination of events included in the CE scenario. In the LTER Reference Case, energy prices rise steadily until about 2020 then stabilize to occupy a relatively narrow range (indicating a long-run equilibrium) once new capacity begins to come on-line. In the CE scenario, energy prices rise slightly until 2015 and then slowly decline thereafter as new, more efficient capacity is constructed. By 2030, wholesale energy prices are 33 percent lower in PJM-SW, 35 percent lower in PJM-MidE, and 36 percent lower in PJM-APS compared to the LTER Reference Case. The graphs below show the real wholesale energy prices for the Maryland zones.

Figure L-18 PJM-SW Real All-Hours Energy Price – Combined Events Scenario

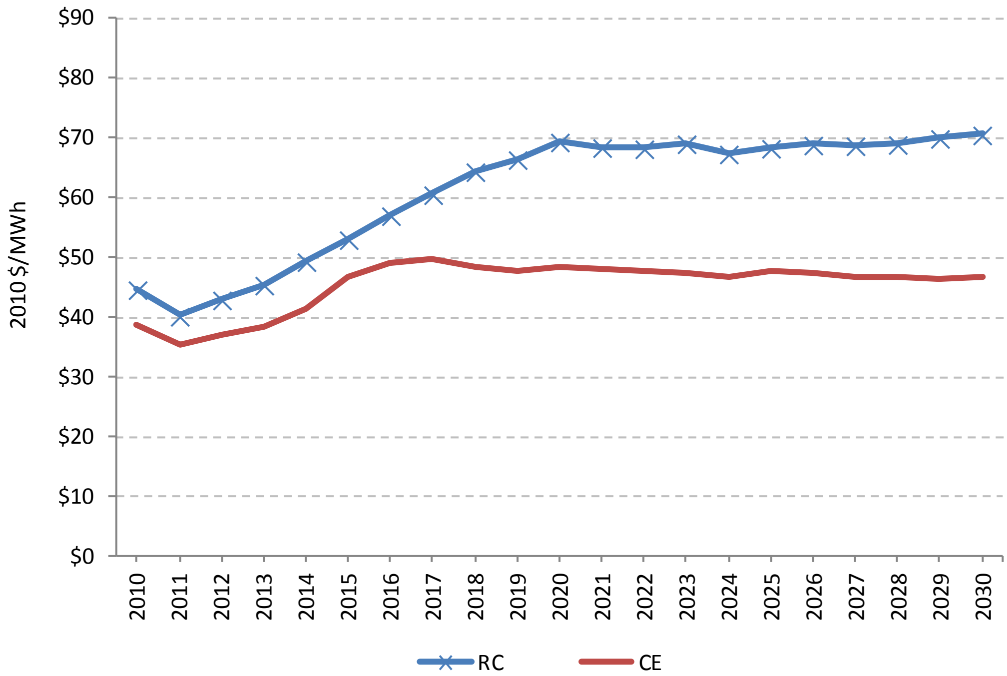


Figure L-19 PJM-MidE Real All-Hours Energy Price – Combined Events Scenario

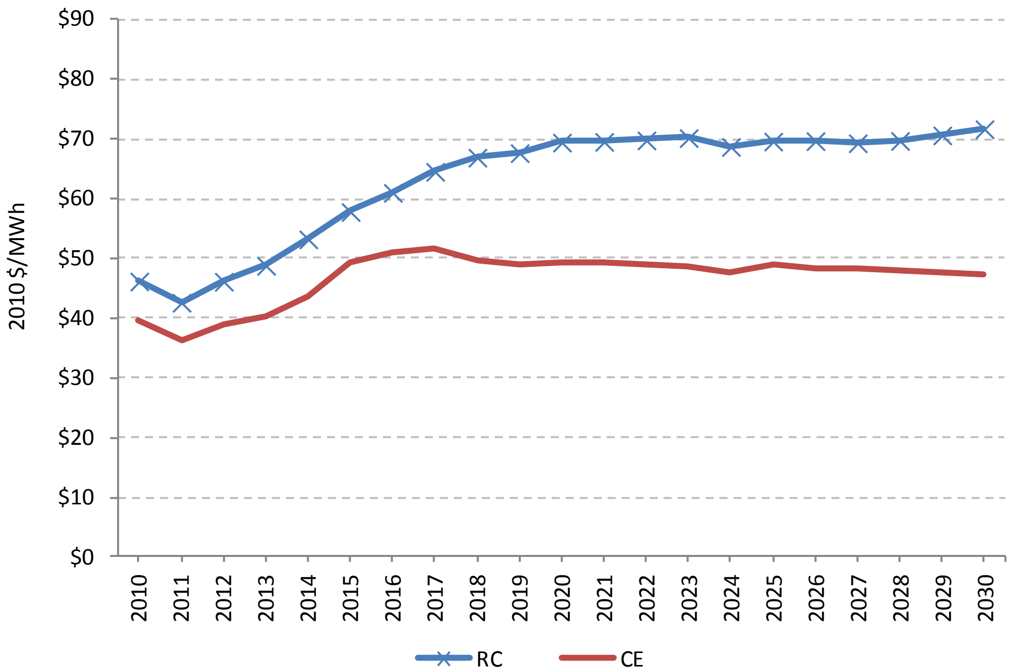
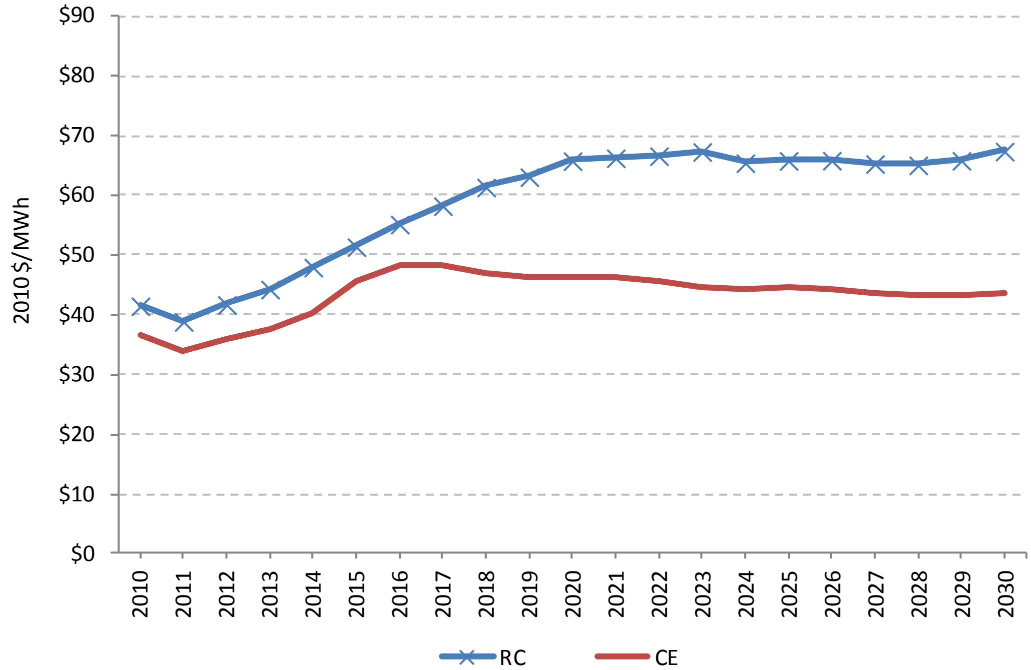


Figure L-20 PJM-APS Real All-Hours Energy Price – Combined Events Scenario



3.4 Capacity Prices

Capacity prices in all three Maryland zones are consistently and significantly higher in the CE scenario compared to the LTER Reference Case due to the much larger amount of new capacity being constructed in each zone in combination with the lower energy prices resulting from lower natural gas prices. Lower energy prices entail higher capacity prices to provide sufficient revenue to marginal units that would otherwise retire. PJM-SW and PJM-APS capacity prices begin to converge towards the LTER Reference Case results in the last few years of the analysis period. As with most scenarios, PJM-MidE capacity prices are more volatile. The graphs below show the capacity prices for the Maryland zones.

Figure L-21 PJM-SW Capacity Prices – Combined Events Scenario

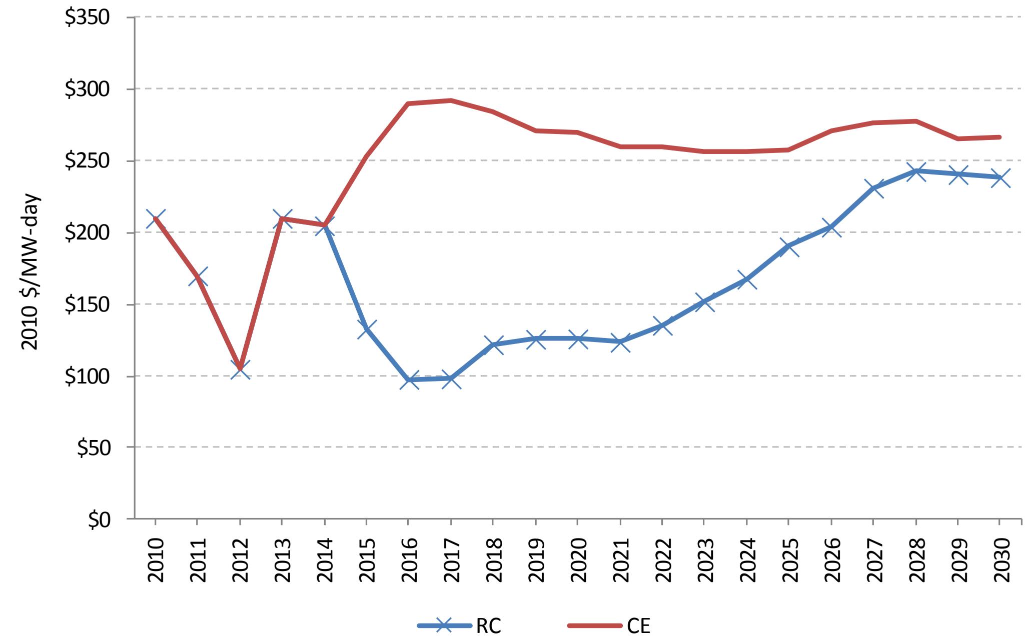


Figure L-22 PJM-MidE Capacity Prices – Combined Events Scenario

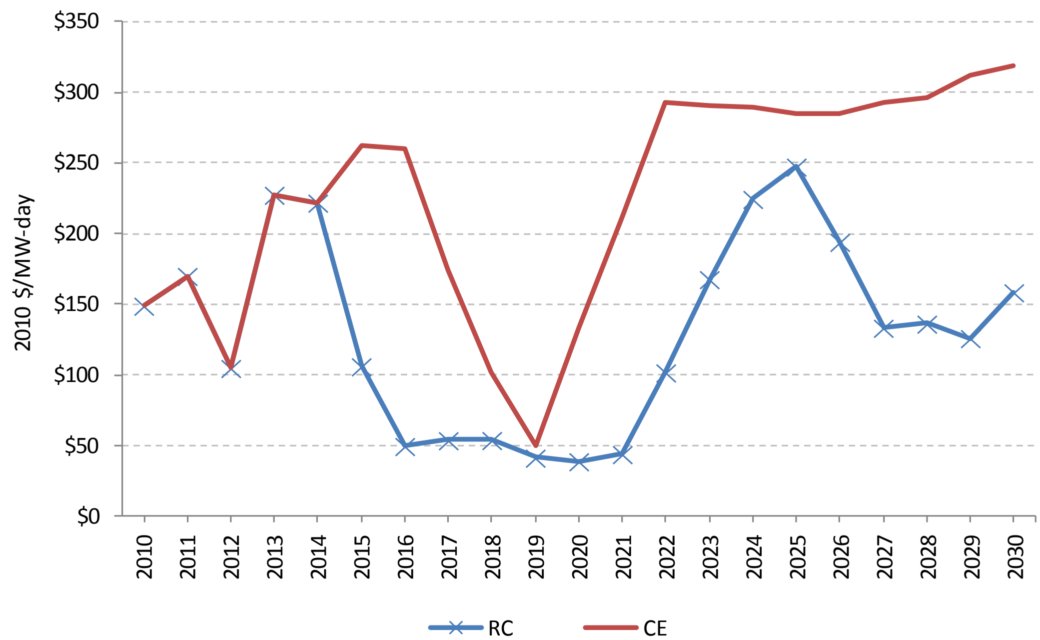
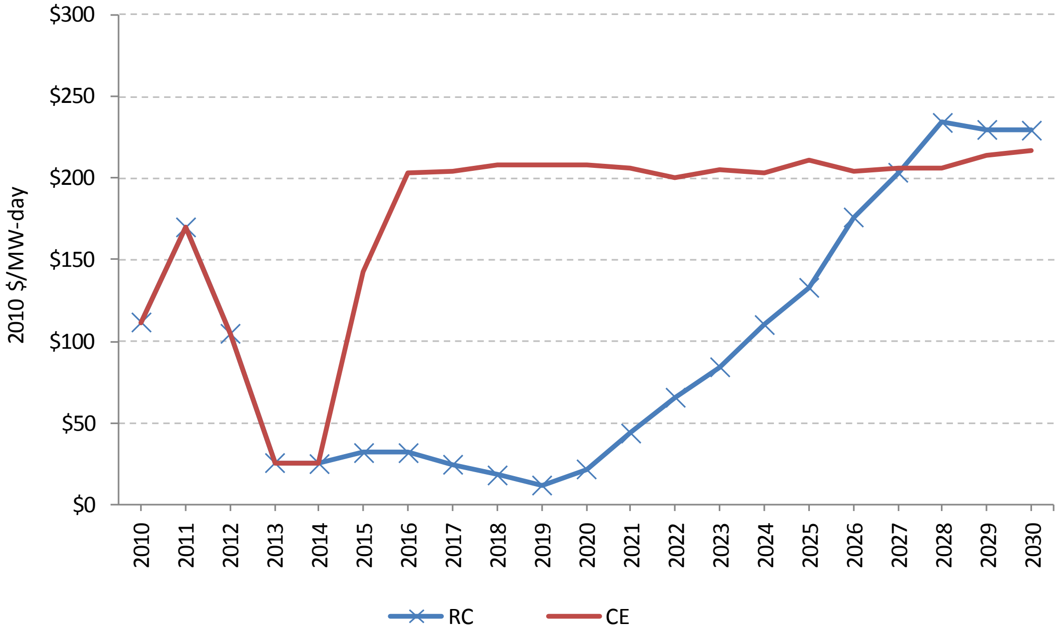


Figure L-23 PJM-APS Capacity Prices – Combined Events Scenario



3.5 Emissions

Emissions of NO_x and SO_2 from power plants subject to the Maryland Healthy Air Act are reduced slightly due to additional retrofits to meet the EPA regulations and the 404 MW of early retirements that occur in 2015 (see Figure L-24 and Figure L-25). Maryland CO_2 emissions from electric generation are affected by the additional retirements and power plant additions. Figure L-26 shows the CO_2 emissions are higher when new capacity starts to be added but then drop to LTER Reference Case levels through the last half of the analysis period as the Maryland fleet as a whole becomes more efficient.

Figure L-24 Maryland HAA Plant SO_2 Emissions – Combined Events Scenario

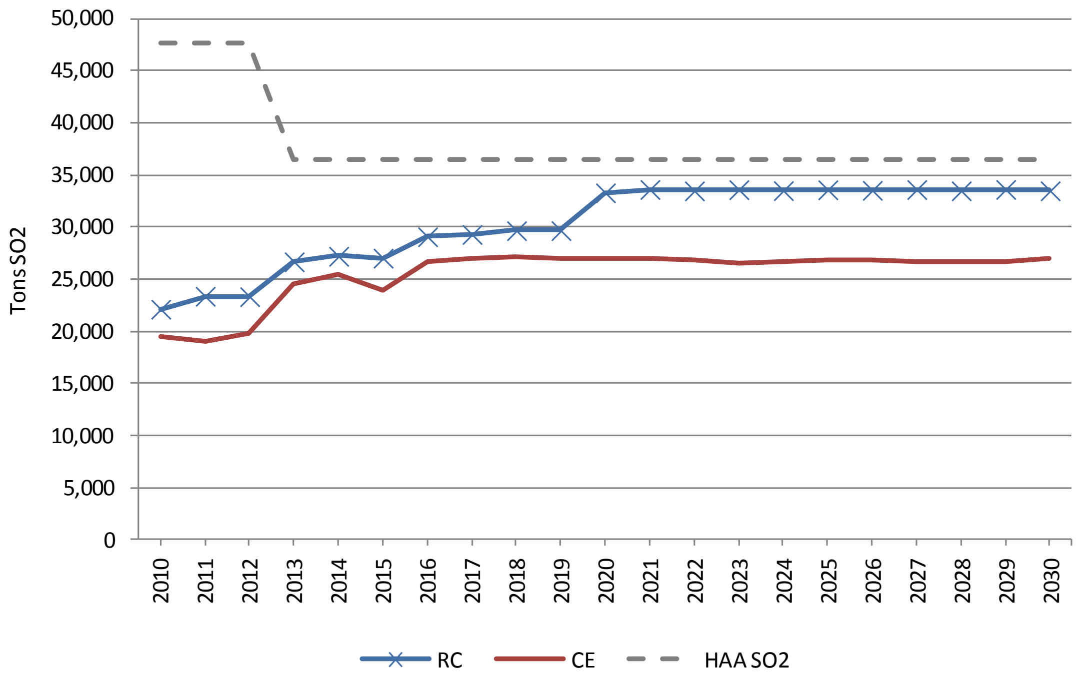


Figure L-25 Maryland HAA Plant NO_x Emissions – Combined Events Scenario

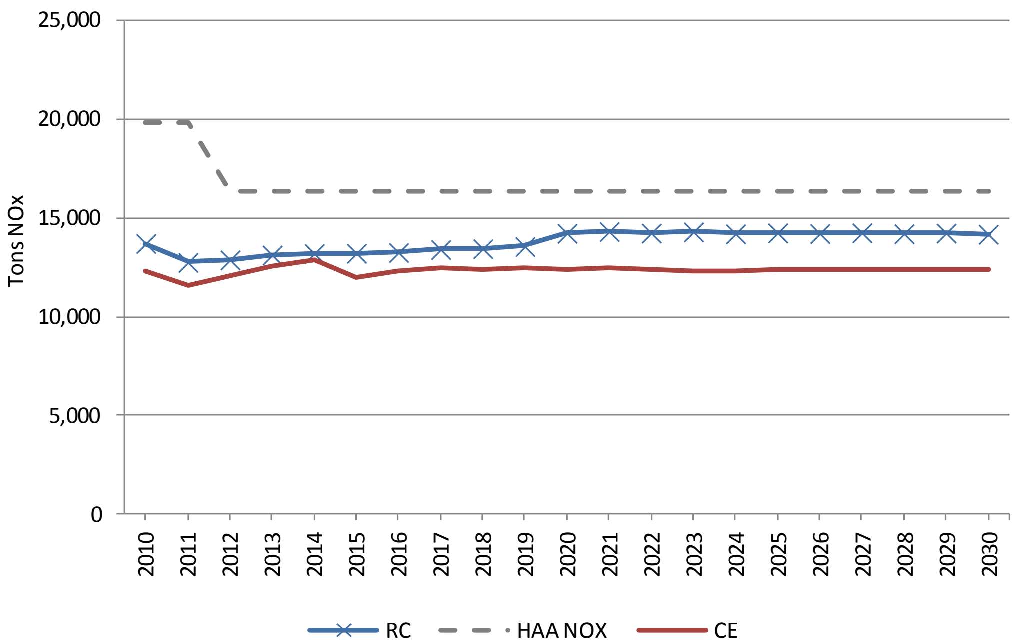
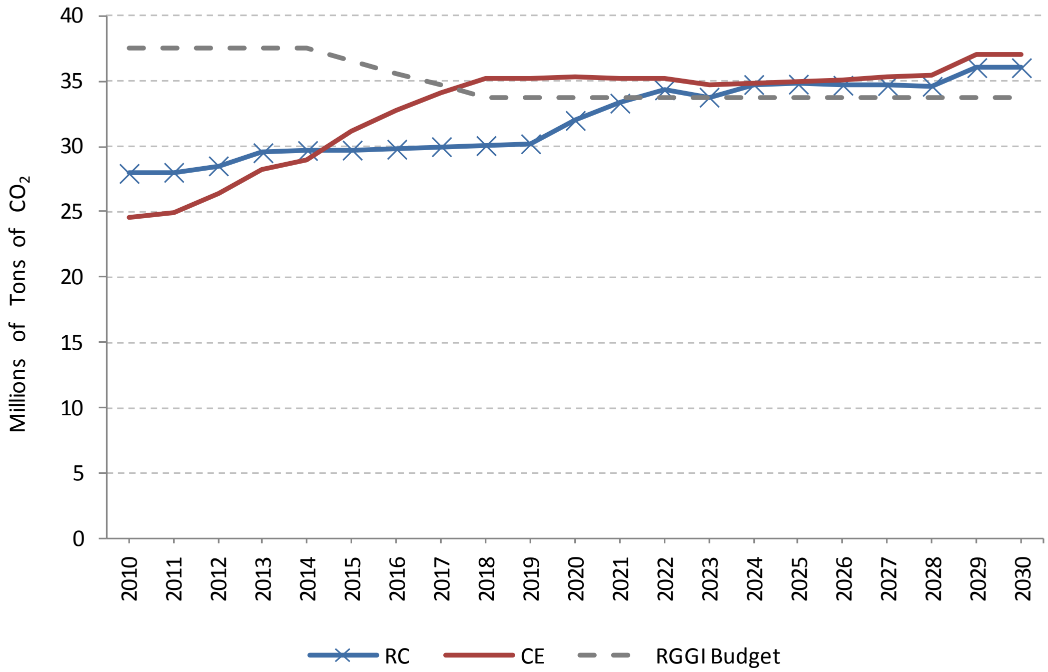


Figure L-26 Maryland Electric Generation CO_2 Emissions – Combined Events Scenario



4. EPA Regulations Scenarios with Additional Retirements

This section of Appendix L contains two additional scenarios that consider the effects of both the current and proposed EPA regulations captured in the EPA scenarios combined with additional coal power plant retirements. The EPA/MSD/AR1 and EPA/MSD/AR2 scenarios adopt the same EPA regulation assumptions as in the EPA scenarios but also include additional coal plant retirements to account for the uncertainty surrounding how the EPA regulations will affect coal-fired power plants. Both of the additional scenarios include the retirements that were announced following the completion of the bulk of the LTER simulation analysis. The EPA/MSD/AR1 includes an additional 14 GW of power plant retirements (11 GW of which is coal-fired) compared to the LTER Reference Case. The EPA/MSD/AR2 scenario includes an additional 25 GW of power plant retirements (22 GW of which is coal-fired) compared to the LTER Reference Case. Both the EPA/MSD/AR1 and EPA/MSD/AR2 scenarios include the Mount Storm to Daubs transmission project.

The extra retirements in the two EPA retirement sensitivity scenarios are based on recently announced power plant retirements and power plant earnings before deducting interest, taxes, depreciation, and amortization ("EBITDA"). In the EPA/MSD/AR1 scenario, the coal plants with the highest SO_2 emissions rates and EBITDAs below $5 million in 2015 were retired. In the EPA/MSD/AR2 scenario, coal plants with the highest SO_2 emissions rates and EBITDAs below $20 million in 2015 were retired. The level of retirements in the EPA/MSD/AR1 and

EPA/MSD/AR2 scenarios approximate the level of coal plants identified by PJM as at "high risk" and at "risk" for retirement, respectively.[2]

4.1 Capacity Additions

Capacity additions in the EPA/MSD/AR1 and EPA/MSD/AR2 scenarios begin earlier than in the LTER Reference Case due to the additional 14 GW and 25 GW of power plant retirements, respectively. Table L-7 shows the capacity additions under the EPA/MSD/AR1 scenario. Several PJM zones begin adding combined cycle natural gas power plants in 2015 and 2016. By 2030, PJM is projected to add 36.4 GW of natural gas capacity, which is approximately 6.2 GW more than shown for the Reference Case plus MSD scenario.

Table L-7 Cumulative Generic Capacity Additions in the EPA/MSD/AR1 Scenario (MW)

Year	PJM-AEP	PJM-APS	PJM-CE	PJM-S	PJM-MidE	PJM-EPA	PJM-SW	PJM-WPA	CIN	FE-ATSI	PJM Total
2010	-	-	-	-	-	-	-	-	-	-	-
2011	-	-	-	-	-	-	-	-	-	-	-
2012	-	-	-	-	-	-	-	-	-	-	-
2013	-	-	-	-	-	-	-	-	-	-	-
2014	-	-	-	-	-	-	-	-	-	-	-
2015	-	-	-	-	-	477	-	477	-	-	954
2016	-	477	-	477	-	954	477	954	-	-	3,339
2017	-	954	-	954	-	1,431	954	1,431	-	-	5,724
2018	-	1,431	-	954	-	1,908	1,431	1,908	-	-	7,632
2019	-	1,908	-	1,431	-	2,385	1,431	2,385	-	-	9,540
2020	-	2,385	-	1,908	-	2,862	1,431	2,862	-	-	11,448
2021	-	2,862	-	2,385	-	3,339	1,431	3,339	-	-	13,356
2022	-	3,339	-	2,862	-	3,339	1,605	3,816	-	-	14,961
2023	-	3,816	-	3,339	-	3,816	1,779	4,293	-	-	17,043
2024	-	4,293	-	3,816	174	3,816	1,779	4,770	-	-	18,648
2025	-	4,770	-	4,293	522	3,816	1,779	5,247	-	-	20,427
2026	-	5,247	174	4,944	870	3,816	1,779	5,247	-	477	22,553
2027	-	5,724	174	5,769	1,347	3,816	1,779	5,724	-	954	25,286
2028	477	6,201	522	6,767	1,694	3,816	1,779	5,724	-	1,431	28,411
2029	954	6,678	522	7,592	2,042	3,816	1,779	6,201	-	1,908	31,492
2030	1,908	7,155	1,043	8,591	2,519	3,816	1,779	6,678	477	2,385	36,351

[2] PJM, *Coal Capacity at Risk for Retirement in PJM: Potential Impacts of the Finalized EPA Cross State Air Pollution Rule and Proposed National Emissions Standards for Hazardous Air Pollutants*, October 5, 2011.

Table L-8 shows the cumulative natural gas capacity by year under the EPA/MSD/AR2 scenario, which an additional 25 GW of retirements in 2015. PJM constructs a little over 43 GW by 2030 in the EPA/MSD/AR2 scenario compared to 36.4 GW in the EPA/MSD/AR1 scenario.

Table L-8 Cumulative Generic Capcity Additions in the EPA/MSD/AR2 Scenario (MW)

Year	PJM-AEP	PJM-APS	PJM-CE	PJM-S	PJM-MidE	PJM-EPA	PJM-SW	PJM-WPA	CIN	FE-ATSI	PJM Total
2,010	-	-	-	-	-	-	-	-	-	-	-
2,011	-	-	-	-	-	-	-	-	-	-	-
2,012	-	-	-	-	-	-	-	-	-	-	-
2,013	-	-	-	-	-	-	-	-	-	-	-
2,014	-	-	-	-	-	-	-	-	-	-	-
2,015	-	477	-	1,431	1,431	477	477	651	-	-	4,944
2,016	-	954	-	2,385	1,908	954	1,128	1,824	-	-	9,152
2,017	-	1,431	-	3,036	1,908	1,431	1,605	2,301	-	-	11,711
2,018	477	1,908	-	3,513	1,908	1,908	2,082	2,778	477	477	15,527
2,019	954	2,385	-	3,990	1,908	2,385	2,082	3,255	477	477	17,912
2,020	1,431	2,862	-	4,467	1,908	2,862	2,082	3,732	477	954	20,774
2,021	1,431	3,339	-	4,944	1,908	3,339	2,082	4,209	477	954	22,682
2,022	1,431	3,816	-	5,421	1,908	3,816	2,082	4,686	477	954	24,590
2,023	1,431	4,293	174	5,898	1,908	4,293	2,082	5,163	477	954	26,672
2,024	1,431	4,770	174	6,375	1,908	4,293	2,082	5,640	477	954	28,103
2,025	1,605	5,247	174	6,852	1,908	4,293	2,082	5,640	477	1,431	29,708
2,026	1,779	5,724	348	7,374	1,908	4,293	2,082	6,117	477	1,908	32,009
2,027	2,256	6,201	348	7,851	1,908	4,293	2,082	6,594	477	2,385	34,394
2,028	2,733	6,678	696	8,894	2,256	4,293	2,082	6,594	651	2,862	37,738
2,029	3,210	7,155	696	9,371	2,778	4,293	2,082	6,594	1,128	3,339	40,644
2,030	3,687	7,632	696	9,848	2,951	4,293	2,082	7,071	1,128	3,816	43,203

PJM-SW and PJM-APS begin adding new natural gas capacity in 2016 under the EPA/MSD/AR1 scenario and in 2015 under the EPA/MSD/AR2 scenario. PJM-MidE is a strong importing zone and therefore does not add new capacity until 2024 in the EPA/MSD/AR1 scenario, which is similar to the Reference Case plus MSD scenario result for PJM-MidE (PJM-MidE adds new capacity beginning in 2023 in the Reference Case plus MSD scenario). The following three graphs show the capacity additions compared to the LTER Reference Case plus MSD scenario. The PJM-SW zone builds new capacity for three years under both EPA/MSD/AR1 and EPA/MSD/AR2 and then requires only two peaking plants in the EPA/MSD/AR1 scenario in 2022 and 2023 but needs no more additional new builds in the EPA/MSD/AR2 scenario. The PJM-MidE zone needs relatively little new capacity, relying instead on increased imports in the EPA/MSD/AR1 scenario, but does initially build several new plants over two years (2015 and 2016) in the EPA/MSD/AR2 scenario. The PJM-APS zone builds a significant amount of extra new natural gas capacity relative to the Reference Case plus MSD scenario throughout the period, some of which is used to generate electricity that is exported to other PJM zones.

Figure L-27 PJM-SW Natural Gas Capacity Additions – EPA Plus Additional Retirements Scenarios

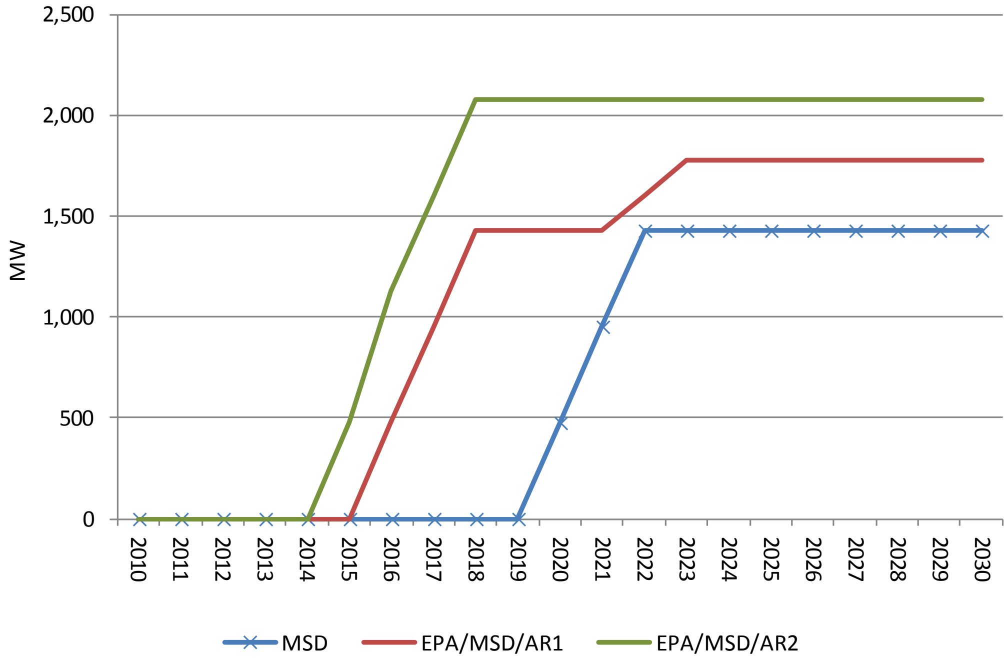


Figure L-28 PJM-MidE Natural Gas Capacity Additions – EPA Plus Additional Retirements Scenarios

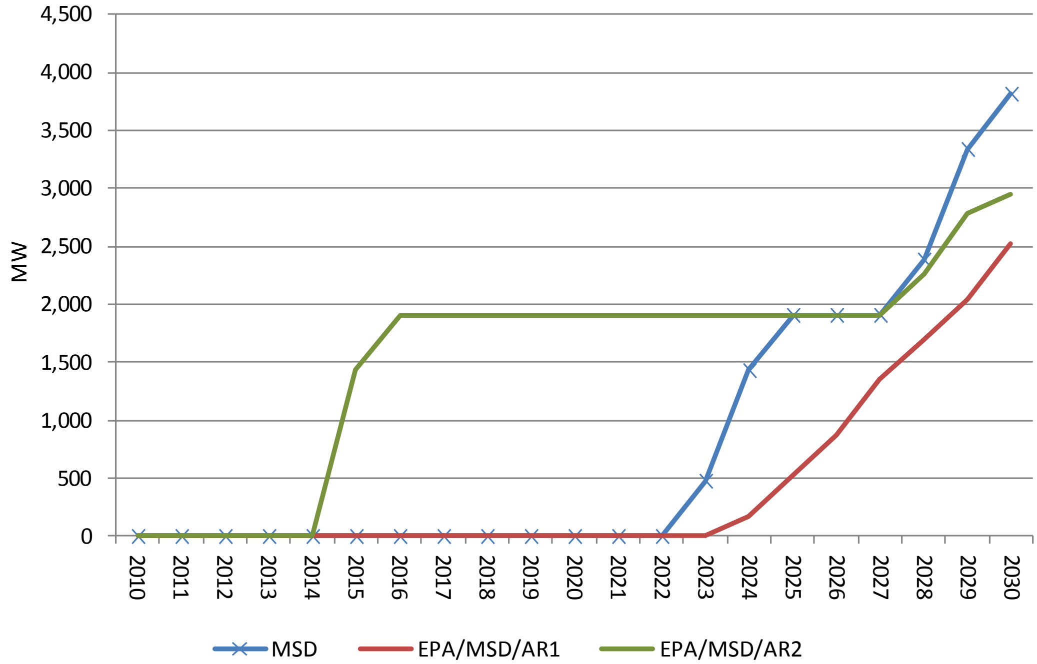
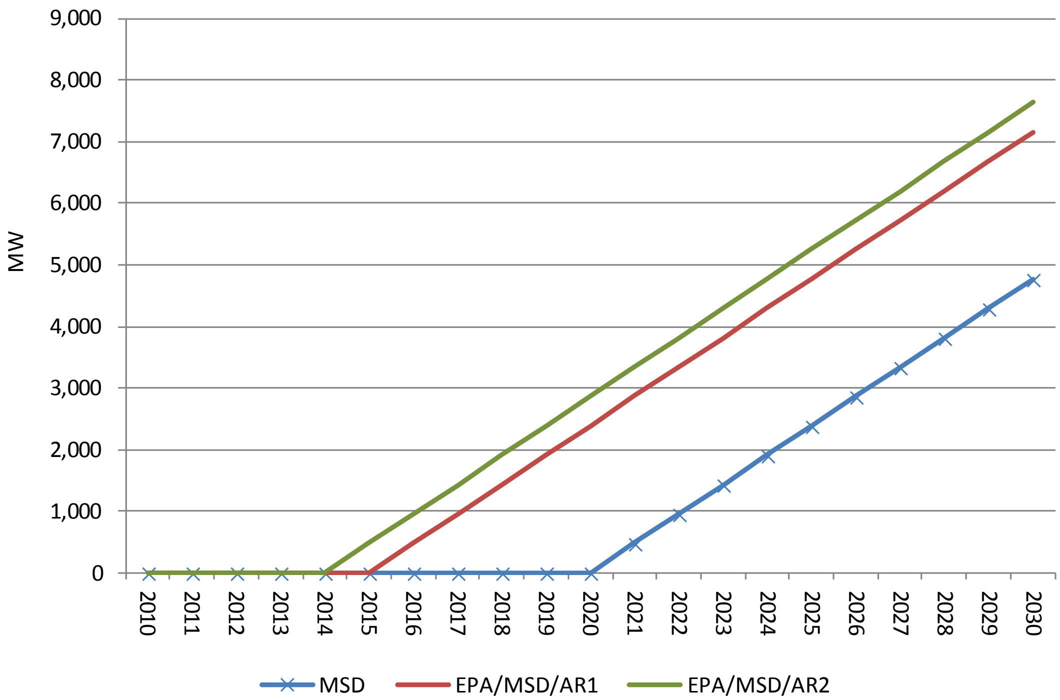


Figure L-29 PJM-APS Natural Gas Capacity Additions – EPA Plus Additional Retirements Scenarios



4.2 Net Imports

The three graphs below show the net imports for the three Maryland zones. Net imports follow a different pattern under the two EPA retirement sensitivity scenarios. Note that net imports differ before 2015 in both the EPA/MSD/AR1 and EPA/MSD/AR2 scenarios because both include the most recently announced retirements, including the Potomac River Generating Station in the PJM-SW region. Under the EPA/MSD/AR1 assumptions, net exports drop in PJM-SW between 2014 and 2017 as new capacity is added and then begin to rebound after 2018 when the PJM-SW region stops building new capacity. PJM-SW net imports are initially lower under the EPA/MSD/AR2 scenario than they are in the Reference Case plus MSD scenario because of the new capacity but by the end of the period, the two scenarios closely track each other. The PJM-MidE zone imports significantly more energy under the EPA/MSD/AR1 scenario than it does under the EPS/MSD/AR2 scenario (or under the Reference Case plus MSD scenario) because that zone builds significantly more capacity when an additional 25 GW of capacity is retired in PJM compared to the additional 14 GW of capacity retired in the EPA/MSD/AR1 scenario. The APS zone also has retirements, so some of the new units constructed must be used to serve native load in that zone. Under EPA/MSD/AR2 scenario, the PJM-APS zone exports less energy to other zones than it does under the Reference Case plus MSD scenario. In contrast, the PJM-APS zone exports more energy as compared to the Reference Case plus MSD scenario under the EPA/MSD/AR1 scenario because not as much of the new capacity is required to serve native load.

Figure L-30 PJM-SW Net Imports – EPA Plus Additional Retirements Scenarios

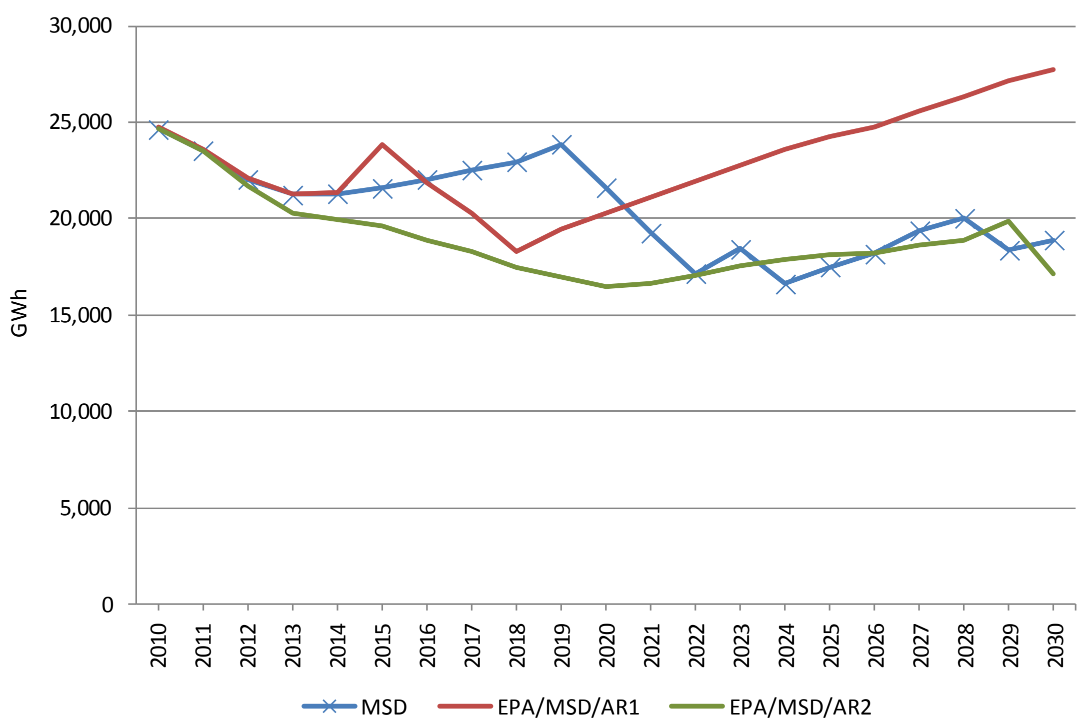


Figure L-31 PJM-MidE Net Imports – EPA Plus Additional Retirements Scenarios

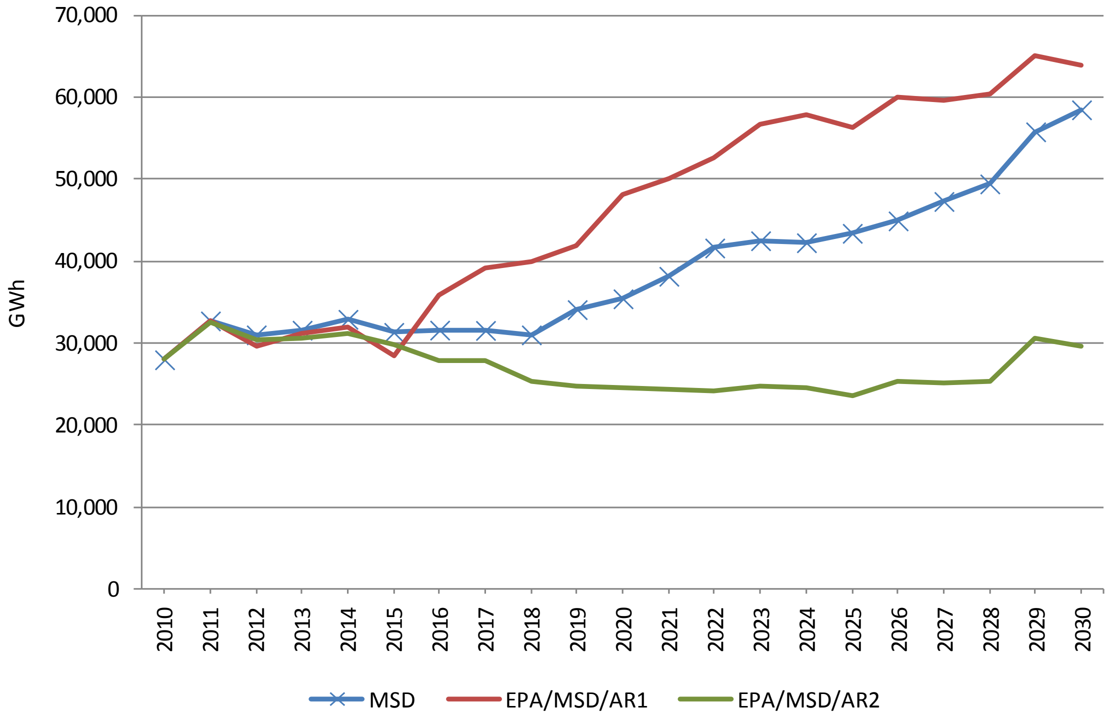
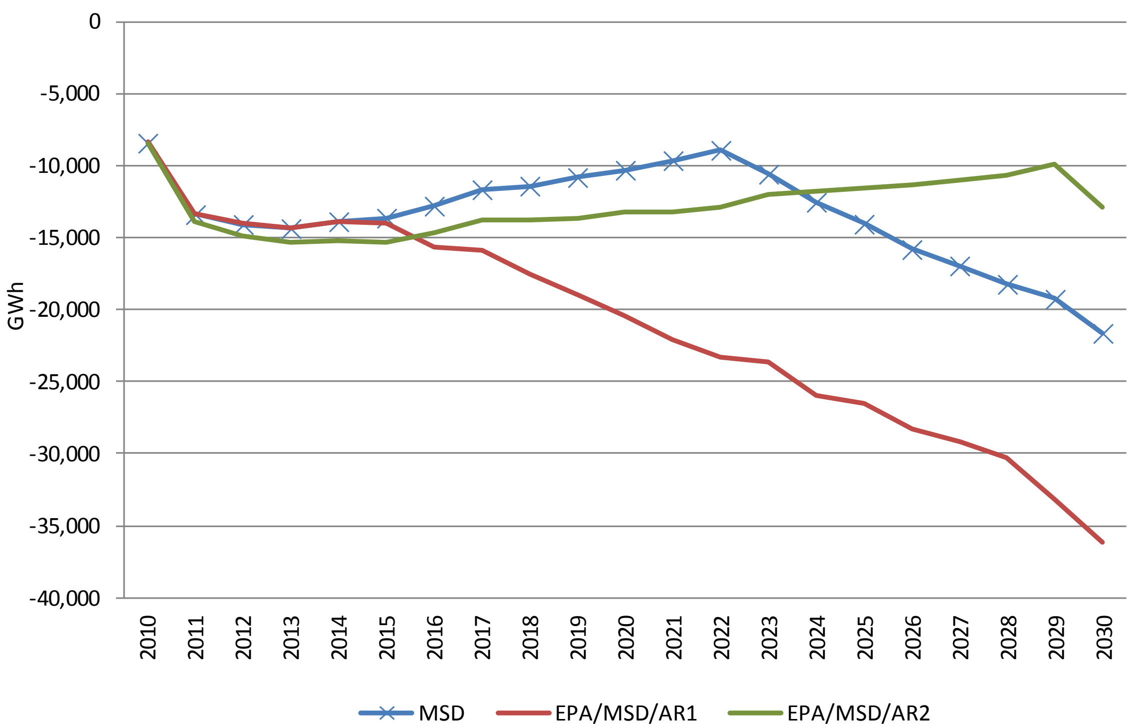


Figure L-32 PJM-APS Net Imports – EPA Plus Additional Retirements Scenarios



4.3 Energy Prices

Energy prices are slightly affected in the short-run as new capacity begins to come on-line in PJM. In all three Maryland zones, wholesale energy prices are higher during the 2016 to 2018 time period but then drop below the Reference Case plus MSD energy prices as more efficient power plants begin to increase PJM fleet efficiency. Prices in all three zones begin to converge towards the MSD result at the end of the analysis period. The graphs below show the real wholesale energy prices for the Maryland zones.

Figure L-33 PJM-SW Real All-Hours Energy Prices – EPA Plus Additional Retirements Scenarios

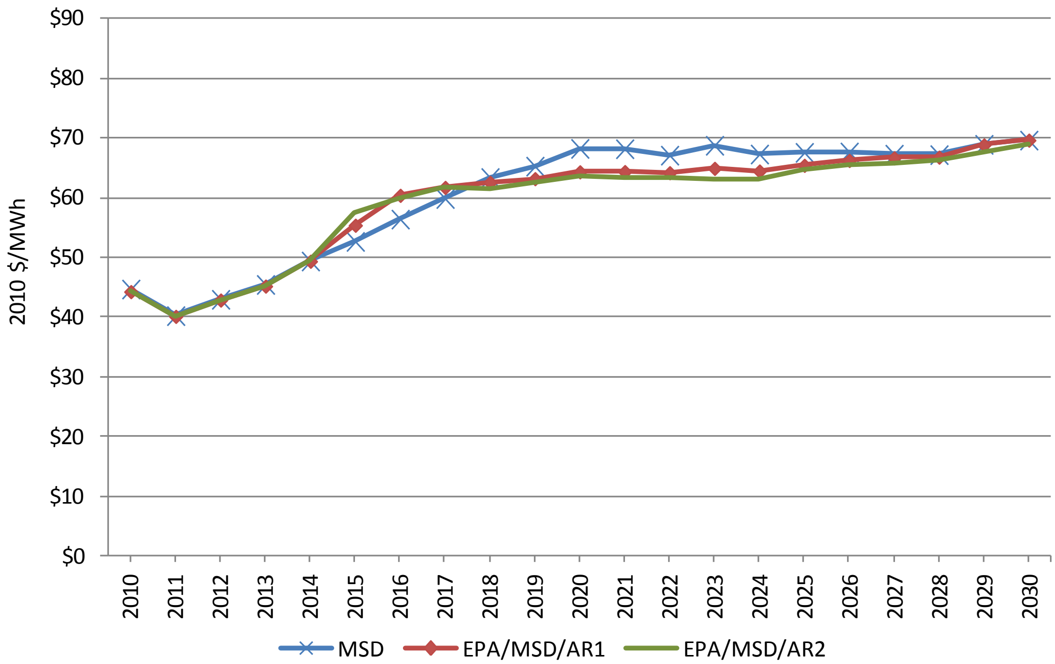


Figure L-34 – PJM-MidE Real All-Hours Energy Price – EPA Plus Additional Retirements Scenarios

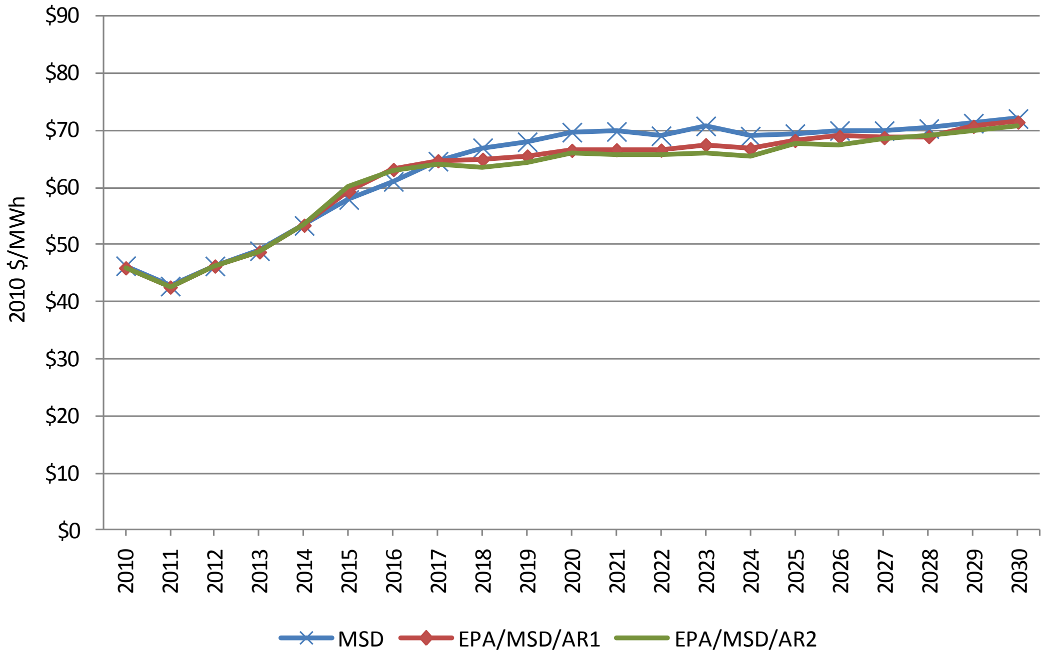
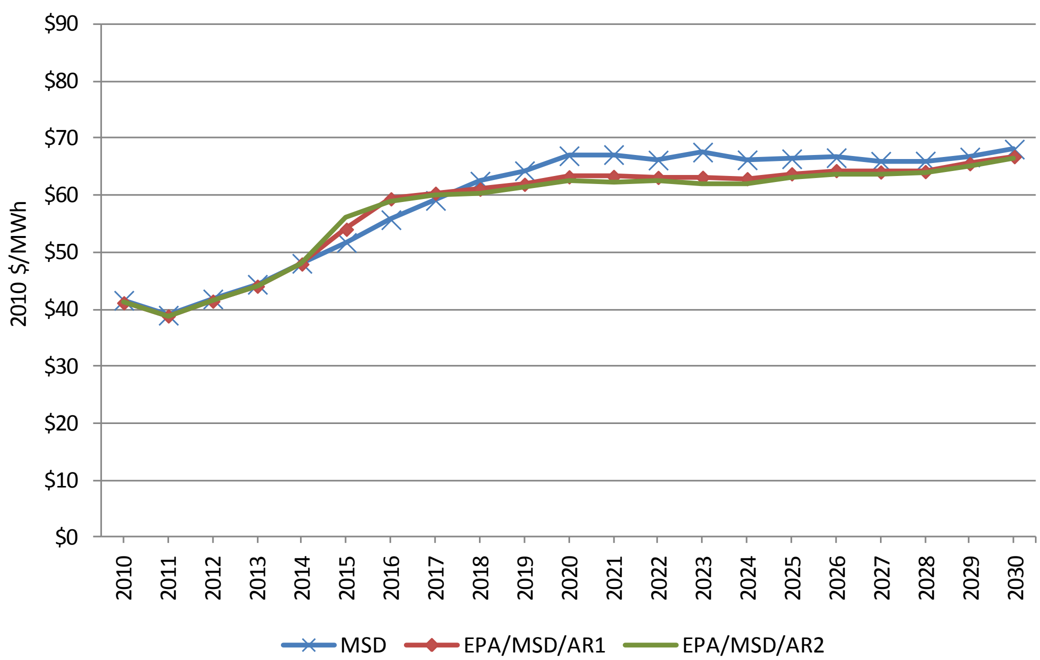


Figure L-35 PJM-APS Real All-Hours Energy Price – EPA Plus Additional Retirements Scenarios



4.4 Capacity Prices

Capacity prices exhibit increased volatility in the EPA plus additional retirements scenarios. Figure L-36 shows the capacity prices for PJM-SW. Capacity prices in PJM-SW rise above the Reference Case plus MSD capacity prices in 2015 and remain higher through the mid-2020s. After 2025, capacity prices in the two EPA plus additional retirements scenarios drops below the Reference Case plus MSD capacity prices. This pattern in PJM-SW capacity prices results because PJM-SW adds new capacity in the earlier years (2016 through 2018) and then does not build any additional new plants (except the two peaking units in 2023 and 2024) in the EPA/MSD/AR1 scenario. In the EPA/MSD/AR2 scenario, PJM-SW builds additional capacity in the years 2015 through 2018 after which no more new capacity is added to the zone, resulting in capacity prices that generally decline after 2018 through the end of the analysis period.

Figure L-36 PJM-SW Capacity Prices – EPA Plus Additional Retirements Scenarios

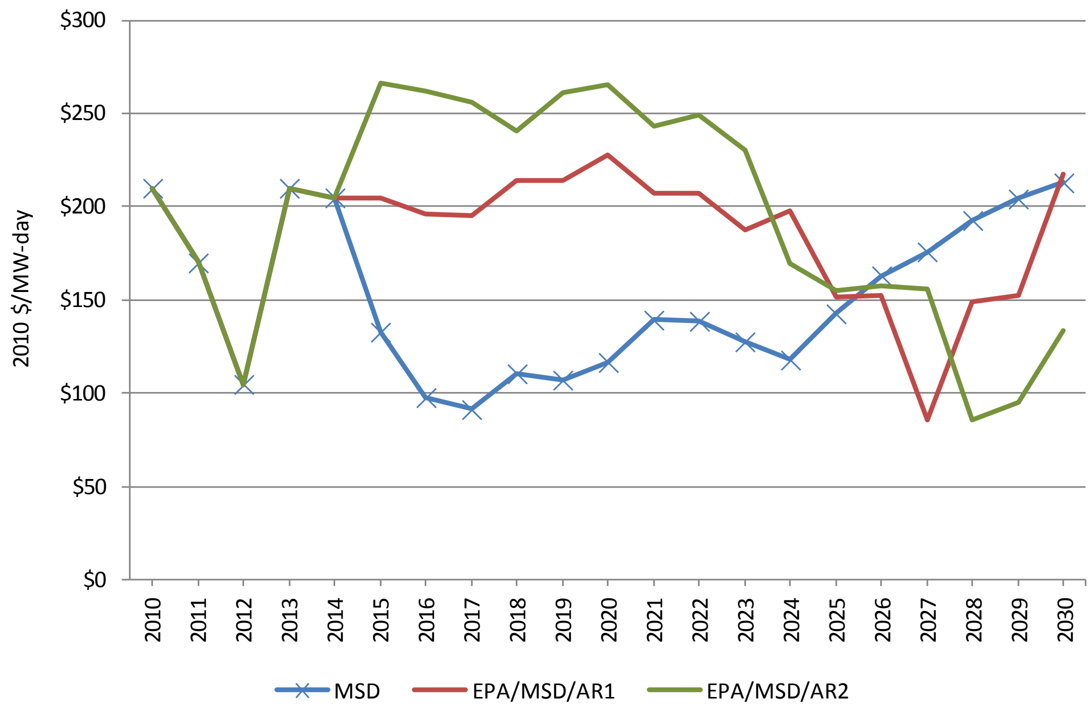


Figure L-37 shows capacity prices for PJM-MidE. In both of the EPA plus additional retirements scenarios, PJM-MidE builds similar amounts of new capacity as was built in the MSD scenario. Therefore, capacity prices follow a similar general pattern in all three scenarios.

Figure L-38 shows the capacity prices for PJM-APS. Due to being a strong exporting zone, PJM-APS starts to build new capacity in 2015 in EPA/MSD/AR2 and in 2016 in

EPA/MSD/AR1, and then continues to build throughout the analysis period resulting in relatively high and stable capacity prices.

Figure L-37 PJM-MidE Capacity Prices – EPA Plus Additional Retirements Scenarios

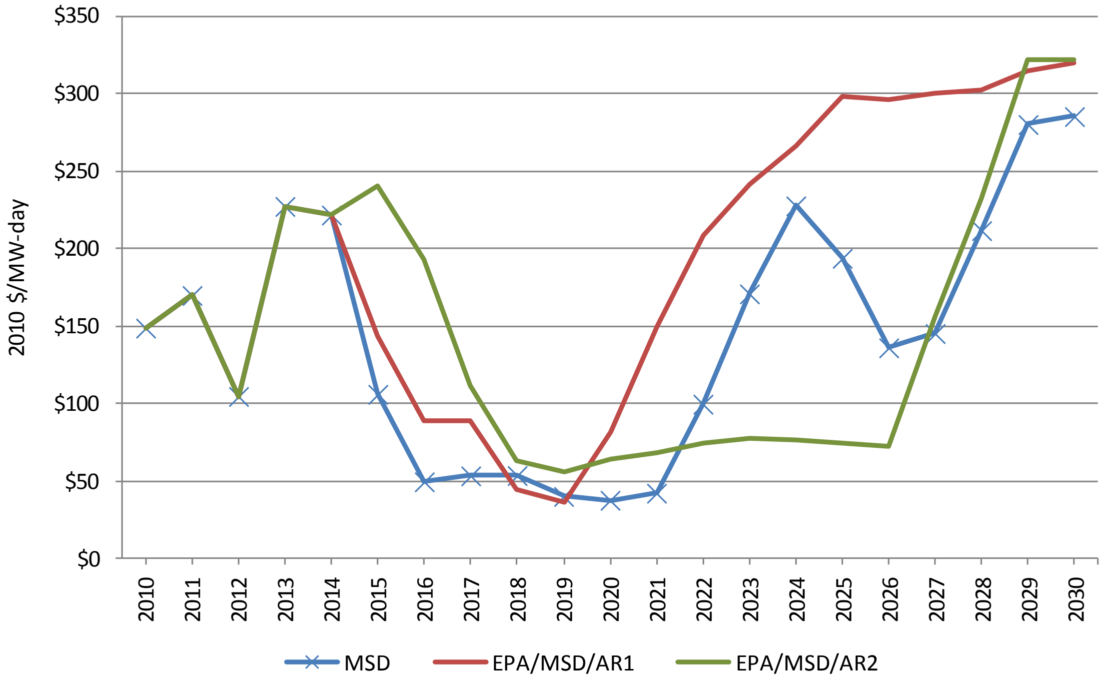
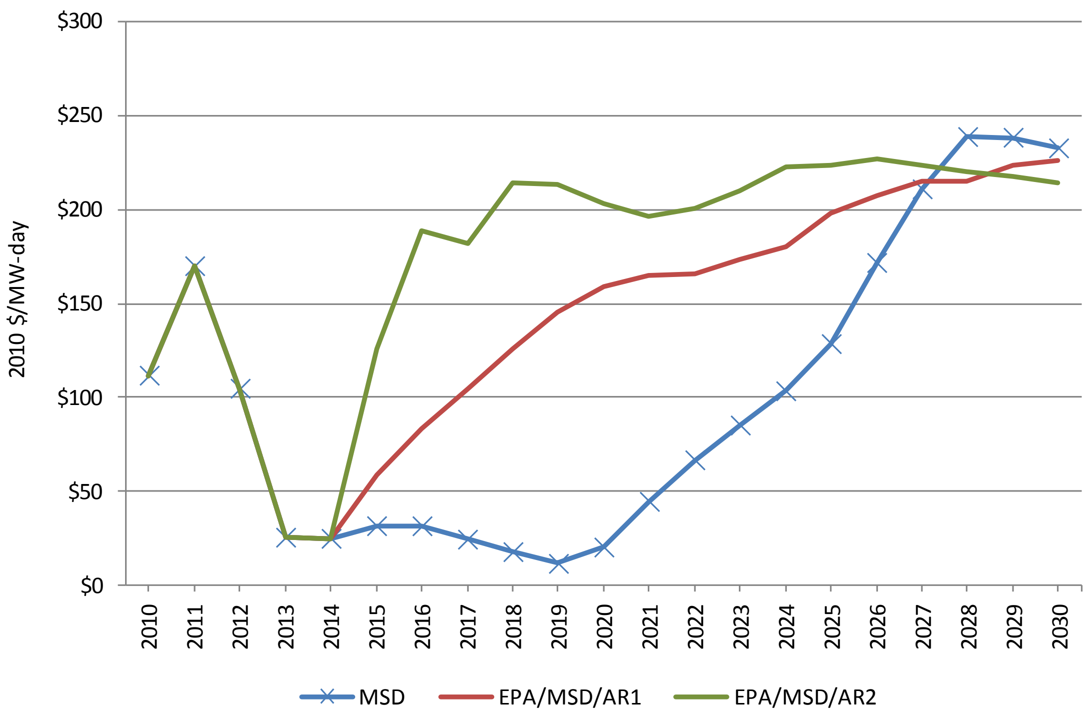


Figure L-38 PJM-APS Capacity Prices – EPA Plus Additional Retirements Scenarios



4.5 Emissions

Emissions of NO_x and SO_2 from power plants subject to the Maryland Healthy Air Act are reduced due to the retrofits to meet the EPA regulations and the 404 MW of early retirements that occur in 2015 (see Figure L-39 and Figure L-40). Maryland CO_2 emissions from electric generation are affected by the additional retirements and power plant additions. Figure L-41 shows the CO_2 emissions are higher when new capacity starts to be added but then hold steady as very little additional new capacity is constructed in Maryland after 2018. Total electric generation CO_2 emissions are similar to CO_2 emissions in the Reference Case plus MSD scenario result through the last ten years of years of the analysis period as Maryland builds similar amounts of new capacity in the EPA plus additional retirements scenarios compared to the MSD scenario.

Figure L-39 Maryland HAA Plant SO_2 Emissions – EPA Plus Additional Retirements Scenarios

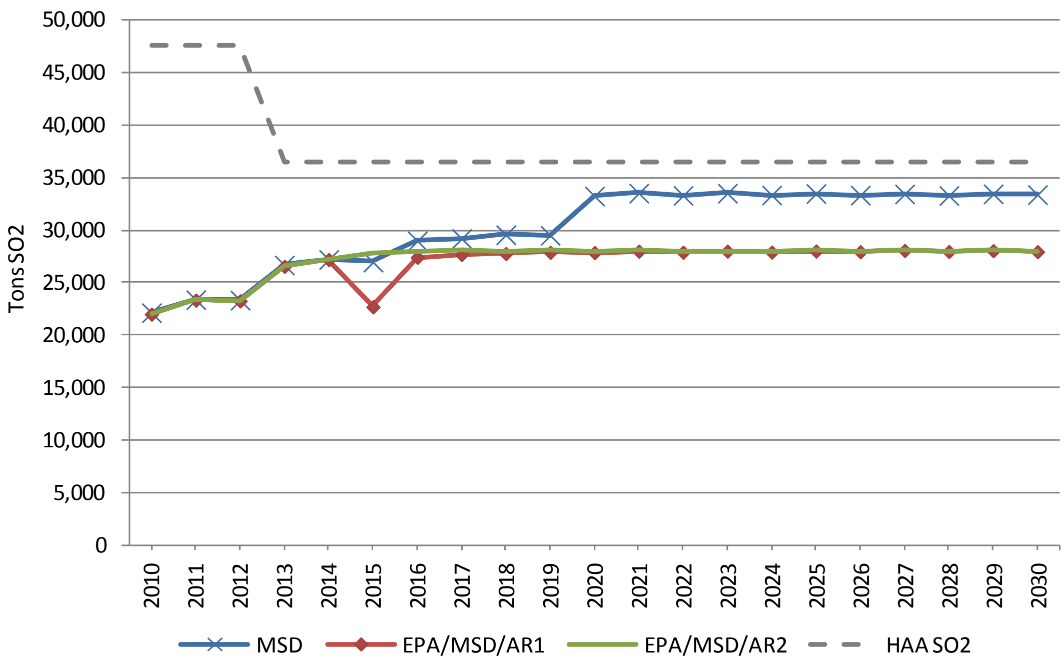


Figure L-40 Maryland HAA Plant NO_x Emissions – EPA Plus Additional Retirements Scenarios

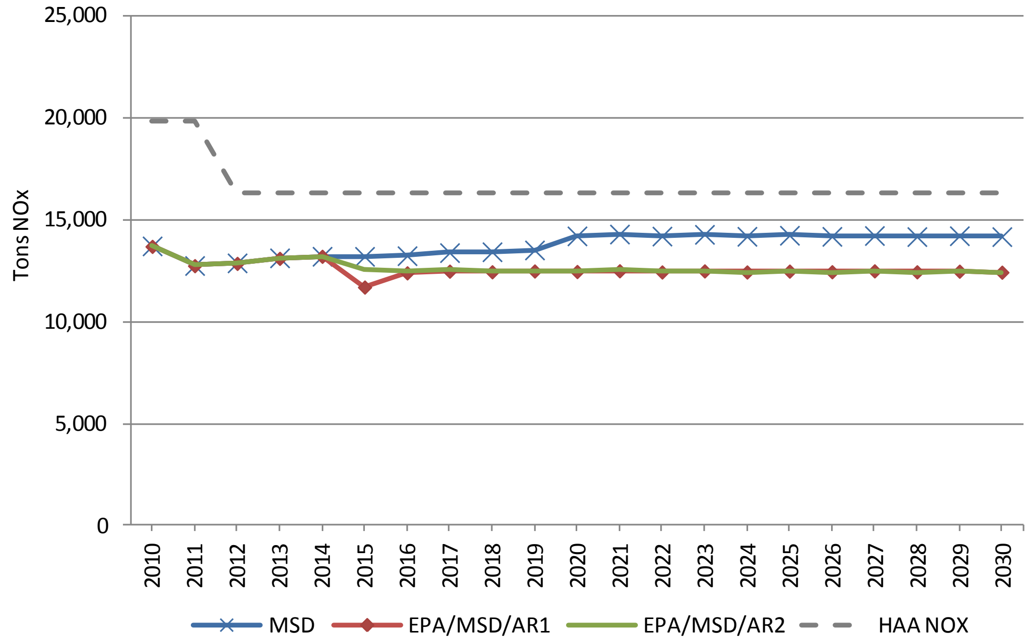
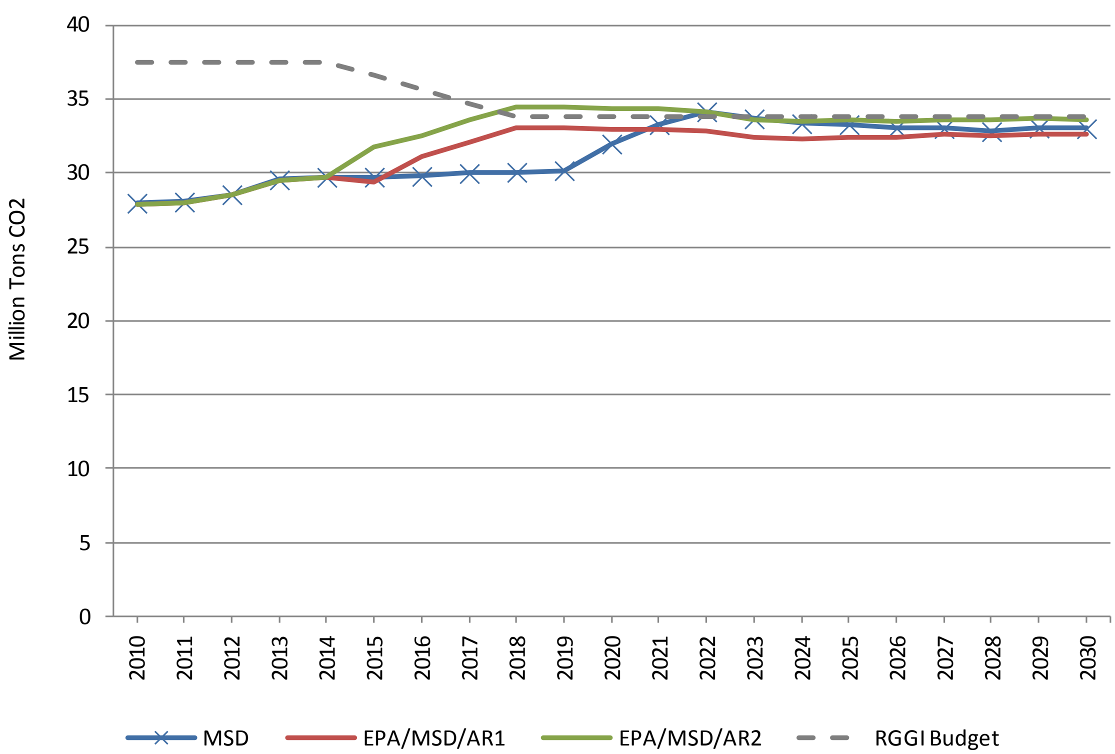


Figure L-41 Maryland Electric Generation CO_2 Emissions – EPA Plus Additional Retirements Scenarios



5. Summary Data

5.1 Introduction

This section presents data for the Supplemental Responsive scenarios analogous to the data presented in Chapter 14 of the LTER report. Chapter 14 contains an evaluation of certain discussion topics and provides a basis by which to compare scenarios to one another. The four Supplemental Responsive Scenarios analyzed in this Appendix are compared to the LTER Reference Case and the MSD scenario. Topics addressed in this section include fuel diversity (Maryland and PJM as a whole), Maryland's consumption-based emissions, energy and capacity costs, net energy imports, new generation capacity requirements, and land use in Maryland.

5.2 Fuel Diversity

This section addresses fuel diversity for the four Supplemental Responsive Scenarios and corresponds to Section 14.2 of the report. Table L-9 and Table L-10 display decennial fuel diversity factors in Maryland and PJM, respectively. Table L-9 corresponds to LTER Tables 14.1, 14.2, and 14.3; Table L-10 corresponds to LTER Tables 14.4, 14.5, and 14.6. For detailed information regarding calculation and interpretation of the fuel diversity factor, refer to Chapter 14, Section 14.2, of the LTER.

Table L-9 Maryland Fuel Diversity

Year	LTER Scenario	Nuclear (%)	Coal (%)	Gas (%)	Renewable (%)	Diversity Factor
2010	Reference Case	31.8	59.9	1.6	6.7	0.71
	MSD	31.8	59.9	1.6	6.7	0.71
	NGP+MSD	31.8	59.9	1.6	6.7	0.71
	CE	34.4	56.4	2.2	7.1	0.74
	EPA/MSD/AR1	31.8	59.9	1.6	6.7	0.71
	EPA/MSD/AR2	31.8	59.9	1.6	6.7	0.71
2020	Reference Case	27.5	58.4	4.5	9.6	0.76
	MSD	27.5	58.5	4.4	9.6	0.76
	NGP+MSD	27.7	58.8	4.1	9.5	0.76
	CE	23.5	48.7	19.7	8.0	0.88
	EPA/MSD/AR1	25.9	54.0	11.2	8.9	0.83
	EPA/MSD/AR2	24.5	51.0	16.2	8.4	0.86
2030	Reference Case	22.9	47.8	21.3	8.0	0.89
	MSD	25.9	54.0	11.0	9.1	0.83
	NGP+MSD	26.0	54.2	10.8	9.0	0.83
	CE	21.8	44.2	26.4	7.6	0.91
	EPA/MSD/AR1	25.9	52.9	12.2	9.0	0.84
	EPA/MSD/AR2	24.8	50.6	15.9	8.6	0.87

Diversity Factor = (1-((%Nuclear^2)+(%Coal^2)+(%Gas^2)+(%Renewable^2)))(4/3)
The data in this table corresponds to the data found in Figures 14.1 through 14.3.

Among the Supplemental Responsive Scenarios, the highest fuel diversity factor for Maryland is observed under the Combined Events scenario. This is primarily attributed to lower natural gas prices and greater natural gas capacity in Maryland relative to the LTER Reference Case. In the Early Natural Gas Plant Scenario, the fuel diversity factors are consistent with the MSD scenario. Under the EPA Regulations with Additional Retirements scenarios, the fuel diversity factors are higher than in the MSD scenario, which is explained by the additional natural gas capacity built in Maryland during the study period and the retirement of certain coal-fired capacity in the State.

With respect to fuel diversity in PJM, we observe the same trends explained above. Note that the fuel diversity factors in PJM are greater than those in Maryland, a result that is consistent with the data presented in Chapter 14.

Fuel diversity in both Maryland and in PJM as a whole increases throughout the analysis period as new natural gas plants are constructed, as coal plants are retired, and as new renewable energy projects are brought on-line. The degree to which the results for any particular scenario reflect these changes in the mix of generating facilities, the fuel diversity factor will correspondingly increase.

Table L-10 PJM Fuel Diversity

Year	LTER Scenario	Nuclear (%)	Coal (%)	Gas (%)	Renewable (%)	Diversity Factor
2010	Reference Case	31.1	57.8	8.0	3.1	0.75
	MSD	31.1	57.8	8.0	3.1	0.75
	NGP+MSD	31.1	57.8	8.0	3.1	0.75
	CE	31.5	56.0	9.5	3.1	0.77
	EPA/MSD/AR1	31.1	57.8	8.0	3.1	0.75
	EPA/MSD/AR2	31.1	57.8	8.0	3.1	0.75
2020	Reference Case	29.3	53.7	9.5	7.5	0.81
	MSD	29.3	53.7	9.5	7.5	0.81
	NGP+MSD	29.3	53.8	9.5	7.4	0.81
	CE	28.8	42.5	21.2	7.4	0.91
	EPA/MSD/AR1	29.1	50.1	13.4	7.5	0.86
	EPA/MSD/AR2	29.4	44.8	18.3	7.5	0.90
2030	Reference Case	25.2	46.9	19.0	8.9	0.90
	MSD	25.3	47.0	18.9	8.8	0.90
	NGP+MSD	25.3	47.0	18.8	8.8	0.90
	CE	24.4	37.5	29.7	8.5	0.94
	EPA/MSD/AR1	25.5	44.6	21.0	8.9	0.91
	EPA/MSD/AR2	25.5	40.5	25.1	8.9	0.93

Diversity Factor = (1-((%Nuclear^2)+(%Coal^2)+(%Gas^2)+(%Renewable^2)))(4/3)
The data in this table corresponds to the data found in Figures 14.4 through 14.6.

5.3 Emissions from Electricity Consumption in Maryland

The following four tables display estimated annual consumption-based emissions in Maryland for SO_2, NO_x, CO_2, and mercury. Additionally, each table includes ten- and twenty-year annual averages, and total emissions for the full 20-year study period. These data are comparable to the data contained in Tables 14.7 through 14.10 of the LTER.

Table L-11 Maryland Consumption-based SO_2 Emissions (tons)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Reference Case	127,900	109,597	84,787	58,724	49,738	39,555	36,857	35,885	35,448	35,379	35,879
MSD	127,900	109,600	84,790	58,727	49,740	39,572	36,877	35,887	35,453	35,390	35,875
NGP + MSD	127,900	109,600	84,790	58,727	49,740	39,898	37,084	36,131	35,664	35,699	35,876
CE	119,927	103,582	79,381	54,839	46,908	25,765	24,580	24,987	24,592	24,214	24,290
EPA/MSD/AR1	127,900	109,598	84,014	58,498	49,551	31,828	30,086	29,164	28,330	28,061	28,249
EPA/MSD/AR2	127,900	109,598	84,014	58,498	49,551	24,664	24,452	24,605	24,446	24,380	24,594

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Reference Case	36,272	36,054	36,180	36,546	35,871	35,455	34,999	34,842	33,455	33,738
MSD	36,272	36,048	36,249	36,501	35,857	35,425	35,022	35,141	33,550	33,781
NGP + MSD	36,267	36,064	36,256	36,591	35,915	35,480	35,035	35,152	33,560	33,777
CE	24,369	24,292	24,094	24,261	24,294	24,463	24,509	24,538	24,750	24,756
EPA/MSD/AR1	28,235	28,158	28,152	28,223	28,409	28,809	28,884	29,249	29,276	29,535
EPA/MSD/AR2	24,627	24,539	24,471	24,633	24,652	24,770	24,822	24,902	25,091	25,046

	2010-2020 Average Annual Emissions	2021-2030 Average Annual Emissions	2010-2030 Average Annual Emissions	2010-2030 Cumulative Emissions
Reference Case	59,068	35,341	47,769	1,003,200
MSD	59,074	35,385	47,793	1,003,700
NGP + MSD	59,192	35,410	47,867	1,005,200
CE	50,279	24,432	37,971	797,400
EPA/MSD/AR1	55,016	28,693	42,481	892,100
EPA/MSD/AR2	52,418	24,755	39,245	824,200

The data in this table corresponds to the data found in Table 14.7.

Table L-12 Maryland Consumption-based NOx Emissions (tons)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Reference Case	40,494	37,907	34,629	30,112	28,951	28,979	27,952	27,887	27,587	27,352	27,635
MSD	40,494	37,907	34,628	30,111	28,951	28,983	27,953	27,882	27,587	27,346	27,628
NGP + MSD	40,494	37,907	34,628	30,111	28,951	29,001	27,975	27,919	27,591	27,378	27,621
CE	38,534	36,390	33,478	29,174	28,334	17,462	15,586	15,601	15,350	15,197	15,378
EPA/MSD/AR1	40,494	37,910	34,391	30,058	28,913	21,677	20,401	20,161	19,804	19,595	19,756
EPA/MSD/AR2	40,494	37,910	34,391	30,058	28,913	15,784	15,397	15,381	15,157	15,040	15,178

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Reference Case	27,704	27,511	27,708	27,914	27,822	27,819	27,597	27,029	26,055	25,757
MSD	27,714	27,509	27,735	27,890	27,822	27,792	27,602	27,058	26,079	25,775
NGP + MSD	27,673	27,504	27,722	27,924	27,830	27,822	27,608	27,036	26,059	25,745
CE	15,393	15,379	15,487	15,672	15,754	15,869	15,957	16,042	16,189	16,327
EPA/MSD/AR1	19,741	19,618	19,686	19,835	19,950	20,139	20,154	20,219	19,812	19,421
EPA/MSD/AR2	15,181	15,089	15,148	15,281	15,336	15,407	15,508	15,602	15,676	15,791

	2010-2020 Average Annual Emissions	2021-2030 Average Annual Emissions	2010-2030 Average Annual Emissions	2010-2030 Cumulative Emissions
Reference Case	30,862	27,292	29,162	612,400
MSD	30,861	27,297	29,164	612,400
NGP + MSD	30,871	27,292	29,167	612,500
CE	23,680	15,807	19,931	418,600
EPA/MSD/AR1	26,646	19,858	23,414	491,700
EPA/MSD/AR2	23,968	15,402	19,889	417,700

The data in this table corresponds to the data found in Table 14.8.

Table L-13 Maryland Consumption-based CO_2 Emissions (thousands of tons)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Reference Case	43,735	42,678	41,811	40,609	39,418	39,468	38,819	39,069	38,611	38,410	38,893
MSD	43,735	42,678	41,811	40,609	39,418	39,470	38,818	39,066	38,612	38,406	38,888
NGP + MSD	43,735	42,678	41,811	40,609	39,418	39,552	38,880	39,152	38,664	38,473	38,885
CE	42,318	41,471	41,075	40,032	39,065	34,244	33,417	33,745	33,524	33,561	34,275
EPA/MSD/AR1	43,735	42,671	41,581	40,522	39,372	37,409	36,735	36,941	36,524	36,409	36,951
EPA/MSD/AR2	43,735	42,671	41,581	40,522	39,372	33,997	33,801	34,028	33,822	33,791	34,347

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Reference Case	39,154	39,107	39,673	40,207	40,283	40,673	40,928	40,982	41,174	41,060
MSD	39,158	39,137	39,690	40,191	40,332	40,644	40,890	40,964	41,151	41,018
NGP + MSD	39,172	39,200	39,727	40,221	40,332	40,668	40,906	40,915	41,123	40,983
CE	34,642	34,712	35,195	35,818	36,082	36,520	36,886	37,198	37,718	38,310
EPA/MSD/AR1	37,165	37,106	37,525	37,973	38,164	38,604	38,937	39,256	39,551	39,444
EPA/MSD/AR2	34,551	34,547	34,943	35,388	35,563	35,958	36,334	36,640	37,070	37,638

	2010-2020 Average Annual Emissions	2021-2030 Average Annual Emissions	2010-2030 Average Annual Emissions	2010-2030 Cumulative Emissions
Reference Case	40,138	40,324	40,227	844,800
MSD	40,137	40,318	40,223	844,700
NGP + MSD	40,169	40,325	40,243	845,100
CE	36,975	36,308	36,657	769,800
EPA/MSD/AR1	38,982	38,373	38,692	812,500
EPA/MSD/AR2	37,420	35,863	36,679	770,300

The data in this table corresponds to the data found in Table 14.9.

Table L-14 Maryland Consumption-based Mercury Emissions (pounds)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Reference Case	2,511	2,431	2,328	2,240	2,164	2,163	2,132	2,144	2,122	2,119	2,132
MSD	2,511	2,432	2,328	2,241	2,165	2,163	2,132	2,144	2,124	2,120	2,132
NGP + MSD	2,511	2,432	2,328	2,241	2,165	2,164	2,134	2,145	2,121	2,119	2,132
CE	2,435	2,370	2,280	2,190	2,119	1,681	1,622	1,631	1,600	1,588	1,600
EPA/MSD/AR1	2,511	2,432	2,303	2,232	2,158	2,013	1,979	1,986	1,949	1,932	1,947
EPA/MSD/AR2	2,511	2,432	2,303	2,232	2,158	1,743	1,731	1,741	1,718	1,704	1,715

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Reference Case	2,144	2,137	2,156	2,167	2,156	2,165	2,168	2,145	2,093	2,043
MSD	2,144	2,138	2,157	2,167	2,157	2,166	2,170	2,148	2,094	2,044
NGP + MSD	2,144	2,139	2,157	2,169	2,158	2,166	2,170	2,148	2,095	2,044
CE	1,605	1,600	1,607	1,614	1,611	1,626	1,625	1,624	1,631	1,629
EPA/MSD/AR1	1,948	1,943	1,961	1,970	1,966	1,988	1,992	1,993	1,971	1,920
EPA/MSD/AR2	1,716	1,715	1,729	1,737	1,733	1,750	1,751	1,753	1,759	1,760

	2010-2020 Average Annual Emissions	2021-2030 Average Annual Emissions	2010-2030 Average Annual Emissions	2010-2030 Cumulative Emissions
Reference Case	2,226	2,137	2,184	45,900
MSD	2,226	2,138	2,185	45,900
NGP + MSD	2,227	2,139	2,185	45,900
CE	1,920	1,617	1,775	37,300
EPA/MSD/AR1	2,131	1,965	2,052	43,100
EPA/MSD/AR2	1,999	1,740	1,876	39,400

The data in this table corresponds to the data found in Table 14.10.

In the Early Natural Gas Plant scenario (which includes the MSD transmission line upgrade), the modeling results indicate no significant changes in average emissions levels during the study period when compared to the MSD scenario. The early addition of one natural gas plant in Maryland has no meaningful impact on the overall emissions levels of the entire PJM fleet, thus consumption-based emissions in Maryland remain basically unchanged.

In the Combined Events scenario, emissions levels are significantly lower than in the LTER Reference Case. The impacts of higher load levels are overshadowed by the effects of large-scale retirements of older generating capacity, combined with the introduction of considerably more natural gas generation capacity and lower natural gas prices in PJM.

In the EPA Regulations with Additional Retirements scenarios, the modeling results also indicate significant reductions in emissions relative to the MSD scenario. The additional plant retirements combined with new EPA regulations result in a newer and cleaner PJM generation fleet over the course of the study period. Under the EPA/MSD/AR2 scenario, the emissions reductions are more pronounced than in the EPA/MSD/AR1 scenario, as a result of the additional incremental coal-plant retirements.

The modeling results suggest that in all of the Supplemental Responsive Scenarios, CO_2 emissions are under the 2006 Greenhouse Gas Reduction Act (GGRA) baseline through 2030 (see Table L-15). This result is consistent with the data presented in Chapter 14.

Table L-15 Percentage Difference in Annual Consumption-Based CO2 Emissions Compared to the 2006 GGRA Baseline CO2 Emissions

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
GGRA Baseline	46,335	46,335	46,335	46,335	46,335	46,335	46,335	46,335	46,335	46,335	46,335
Reference Case	(5.6)	(7.9)	(9.8)	(12.4)	(14.9)	(14.8)	(16.2)	(15.7)	(16.7)	(17.1)	(16.1)
MSD	(5.6)	(7.9)	(9.8)	(12.4)	(14.9)	(14.8)	(16.2)	(15.7)	(16.7)	(17.1)	(16.1)
NGP + MSD	(5.6)	(7.9)	(9.8)	(12.4)	(14.9)	(14.6)	(16.1)	(15.5)	(16.6)	(17.0)	(16.1)
CE	(8.7)	(10.5)	(11.4)	(13.6)	(15.7)	(26.1)	(27.9)	(27.2)	(27.6)	(27.6)	(26.0)
EPA/MSD/AR1	(5.6)	(7.9)	(10.3)	(12.5)	(15.0)	(19.3)	(20.7)	(20.3)	(21.2)	(21.4)	(20.3)
EPA/MSD/AR2	(5.6)	(7.9)	(10.3)	(12.5)	(15.0)	(26.6)	(27.1)	(26.6)	(27.0)	(27.1)	(25.9)

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
GGRA Baseline	46,335	46,335	46,335	46,335	46,335	46,335	46,335	46,335	46,335	46,335
Reference Case	(15.5)	(15.6)	(14.4)	(13.2)	(13.1)	(12.2)	(11.7)	(11.6)	(11.1)	(11.4)
MSD	(15.5)	(15.5)	(14.3)	(13.3)	(13.0)	(12.3)	(11.8)	(11.6)	(11.2)	(11.5)
NGP + MSD	(15.5)	(15.4)	(14.3)	(13.2)	(13.0)	(12.2)	(11.7)	(11.7)	(11.2)	(11.6)
CE	(25.2)	(25.1)	(24.0)	(22.7)	(22.1)	(21.2)	(20.4)	(19.7)	(18.6)	(17.3)
EPA/MSD/AR1	(19.8)	(19.9)	(19.0)	(18.0)	(17.6)	(16.7)	(16.0)	(15.3)	(14.6)	(14.9)
EPA/MSD/AR2	(25.4)	(25.4)	(24.6)	(23.6)	(23.2)	(22.4)	(21.6)	(20.9)	(20.0)	(18.8)

	2010-2020 Average Annual Emissions	2021-2030 Average Annual Emissions	2010-2030 Average Annual Emissions	2010-2030 Cumulative Emissions
GGRA Baseline	46,335	46,335	46,335	973,035
Reference Case	(13.4)	(13.0)	(13.2)	(13.2)
MSD	(13.4)	(13.0)	(13.2)	(13.2)
NGP + MSD	(13.3)	(13.0)	(13.1)	(13.1)
CE	(20.2)	(21.6)	(20.9)	(20.9)
EPA/MSD/AR1	(15.9)	(17.2)	(16.5)	(16.5)
EPA/MSD/AR2	(19.2)	(22.6)	(20.8)	(20.8)

The data in this table corresponds to the data found in Table 14.11.

5.4 PJM Production Costs and Revenues

Table L-16 presents PJM production costs, capital costs of new generation in PJM, and total energy and capacity revenues in PJM during the study period (in millions of 2010 dollars). For a description of the assumptions used to calculate these estimates, please refer to Chapter 14 (Section 14.6).

Table L-16 2010 - 2030 Total PJM Production Costs and Revenues (2010$, millions)

	PJM Production Costs*	Generic Capital Costs**	Energy Revenues	Capacity Revenues	Total Revenues
Reference Case	596,070	80,900	1,066,579	175,436	1,242,016
MSD	595,948	80,737	1,066,541	174,176	1,240,717
NGP+MSD	596,004	80,050	1,065,388	178,702	1,244,090
CE	579,119	139,407	855,391	306,016	1,161,407
EPA/MSD/AR1	607,147	98,561	1,071,347	235,949	1,307,295
EPA/MSD/AR2	612,488	117,390	1,073,134	260,575	1,333,708

*PJM production costs include only variable and fixed O&M costs, fuel costs, and emissions costs.
**PJM capital costs are based on the levelized capital costs of new generation (i.e., generic gas builds and renewable energy projects) and exclude the capital costs of all existing and planned new generation, as these costs do not vary across scenarios.
The data in this table corresponds to the data found in Figures 14.27 through 14.29.

In the Combined Events scenario, PJM production costs and energy revenues are lower than in the LTER Reference Case, primarily due to lower natural gas prices during the forecast period. Capital costs and capacity revenues are significantly higher in the Combined Events scenario resulting from the increased need for new generation in comparison to the LTER Reference Case.

Under the EPA Regulations with Additional Retirements scenarios, capital costs and capacity revenues are higher than in the MSD scenario, also due to the greater need for new generation. PJM productions costs and energy revenues are slightly higher than in the MSD scenario, which is consistent with the other EPA Regulations scenarios in Chapter 14 (see Section 14.6).

5.5 Maryland Energy and Capacity Costs

Table L-17 presents estimated energy and capacity costs in Maryland during the course of the study period (in millions of 2010 dollars).

Table L-17 2010 - 2030 Total Maryland Energy and Capacity Costs (2010$, millions)

	Wholesale Energy Costs in Maryland	Total Capacity Costs in Maryland	Energy plus Capacity Costs in Maryland	Differential from the LTER Reference Case
Reference Case	95,794	20,620	116,414	0
MSD	94,986	18,940	113,926	(2,488)
NGP + MSD	94,785	18,776	113,561	(2,853)
CE	72,671	30,039	102,710	(13,704)
EPA/MSD/AR1	93,508	23,506	117,014	600
EPA/MSD/AR2	92,704	24,543	117,247	833

The data in this table corresponds to the data found in Figures 14.33 through 14.36.

In the Early Natural Gas Plant Scenario, total energy and capacity costs in Maryland are slightly lower (i.e., less than one percent) than in the MSD scenario. Under the Combined Events assumptions, Maryland energy costs are about 24 percent lower than in the LTER Reference Case; however, capacity costs are approximately 46 percent higher during the study period. On net, total energy and capacity costs in the Combined Events scenario are about 12 lower than in the LTER Reference Case.

In the EPA Regulations plus Additional Retirements scenarios, capacity costs in Maryland are projected to be at least 24 percent higher than in the MSD scenario. Lower energy costs, however, partially offset the increased capacity costs, resulting in total costs that are only about 3 percent higher than in the MSD scenario.

5.6 Generic Capacity Additions and Maryland Net Energy Imports

Table L-18 displays the level of capacity additions that are built in PJM and PJM-SW to meet reliability requirements during the study period. The table also displays the first year that new capacity is required to come on-line in the PJM region and in the PJM-SW zone.

Table L-18 Generic Natural Gas Capacity Additions by 2030 (MW)

	PJM Region			PJM-SW		
	Total Capacity by 2030	**Change from RC**	**Year First Plant Built**	**Total Capacity by 2030**	**Change from RC**	**Year First Plant Built**
Reference Case	30,101	0	2018	2,385	0	2020
MSD	30,145	45	2018	1,431	(954)	2020
NGP+MSD	29,494	(606)	2018	954	(1,431)	2021
CE	61,641	31,541	2015	4,994	2,609	2015
EPA/MSD/AR1	36,351	6,250	2015	1,779	(606)	2016
EPA/MSD/AR2	43,203	13,102	2015	2,082	(303)	2015

The data in this table corresponds to the data found in Table 14.18.

The Early Natural Gas Plant scenario pushes back the need for new capacity in PJM-SW by one year. Compared to the MSD scenario, there is no change in total capacity additions in PJM-SW by 2030 (when accounting for the additional natural gas plant).

The Combined Events scenario results in almost 62 GW of generic natural gas capacity additions in PJM by 2030—more than twice the level of capacity additions in the LTER Reference Case. This result is attributable to the combination of higher loads and additional coal plant retirements.

The EPA Regulations and Additional Retirements scenarios require higher levels of capacity additions, relative to the MSD scenario, due to the additional plant retirements that occur in these scenarios. In both the Combined Events scenario and the EPA Regulations and Additional Retirements scenarios, new capacity is required in PJM by 2015, three years in advance of the requirement in the LTER Reference Case.

Table L-19 presents the estimated level of electricity generation and consumption in Maryland in 2020 and 2030. Under each of the Supplemental Responsive Scenarios, Maryland continues to be a net importer of electricity through the end of the study period. Among the four Supplemental Responsive Scenarios, generation in Maryland is projected to be highest under the Combined Events scenario.

Table L-19 Estimated Maryland Electric Energy Generation and Consumption (thousands of MWh)

	Generation		Consumption*		Net Imports		Percentage of Energy Imported	
	2020	2030	2020	2030	2020	2030	2020	2030
Reference Case	53,478	64,291	73,836	81,623	20,358	17,332	28%	21%
MSD	53,377	56,832	73,836	81,623	20,459	24,791	28%	30%
NGP+MSD	53,212	56,690	73,836	81,623	20,624	24,933	28%	31%
CE	62,497	67,425	75,775	85,964	13,278	18,539	18%	22%
EPA/MSD/AR1	56,725	56,718	73,836	81,623	17,111	24,905	23%	31%
EPA/MSD/AR2	60,093	59,260	73,836	81,623	13,743	22,363	19%	27%

*Maryland electric energy consumption estimates include 7 percent transmission and distribution line losses.
The data in this table corresponds to the data found in Table 14.17.

5.7 Land Use Requirements in Maryland

Table L-20 displays estimates for the amount of land required for new generation in Maryland during the study period for the four Supplemental Responsive Scenarios. The analogous estimates for the LTER Reference Case and the MSD scenario are also presented to facilitate comparison. For a description of how these estimates are calculated, please refer to Chapter 14, Section 14.13.

Table L-20 Total Estimated Land Area Required for Generic Capacity Additions in Maryland (acres)

Scenario	Onshore Wind	Solar	Nuclear	Natural Gas	Total
Reference Case	6,720	3,710	0	2,862	13,292
MSD	6,720	3,710	0	1,717	12,147
NGP+MSD	6,720	3,710	0	1,145	11,575
Combined Events	6,720	3,710	0	5,992	16,422
EPA/MSD/AR1	6,720	3,710	0	2,135	12,565
EPA/MSD/AR2	6,720	3,710	0	2,498	12,929

The assumptions regarding renewable capacity additions is invariant across the Supplemental Responsive Scenarios. Most wind energy is imported into Maryland from elsewhere in PJM, and solar is built to an assumed maximum capacity level that meets approximately half of the Maryland Tier 1 Solar RPS requirement. No new nuclear capacity is built under any of Supplemental Responsive Scenarios. As such, the only variation in land use requirements for Maryland is based on the level of natural gas capacity additions identified for the PJM-SW zone.

Under the Early Natural Gas Plant scenario there is no variance in the amount of land used for electricity production in Maryland relative to the MSD scenario (if the additional natural gas plant is added to the level of generic natural gas capacity additions in PJM-SW). Significantly more land area is required in the Combined Events scenario (relative to the LTER Reference Case) owing to the increased natural gas plant capacity constructed under that scenario relative to the LTER Reference Case. The EPA Regulations and Additional Retirements scenarios also require more land area than in the MSD scenario because of new generation required to replace retiring coal-fired capacity.